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PART II:

ENVIRONMENTAL PROTECTION AGENCY

CONTROL OF AIR POLLUTION FROM NEW MOTOR VEHICLES AND NEW MOTOR VEHICLE ENGINES

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Final Evaporative Emission Regulations for Light Duty Vehicles and Trucks

Title 40—Protection of Environment

CHAPTER I—ENVIRONMENTAL PROTECTION AGENCY

[FRL 595–1]

PART 86—CONTROL OF AIR POLLUTION FROM NEW MOTOR VEHICLES AND NEW MOTOR VEHICLE ENGINES

Final Evaporative Emission Regulations for Light Duty Vehicles and Trucks

On January 13, 1976 a notice of proposed rulemaking (NPRM) was published in the FEDERAL REGISTER (41 FR 2022), setting forth proposed amendments to Subparts A and B of Part 86 of the Code of Federal Regulations (CFR) to become effective with 1978 model year light duty vehicles and light duty trucks. The NPRM announced the Agency's intention to revise the evaporative emission test procedures and establish standards of 6 g/test for 1978 and 2 g/test for 1979 and subsequent model years.

The issue of a 2 gram per test standard for 1979 is much more complex than the revised test procedures and the 1978 standard. Yet the current 1978 standard represents so large (about 70%) of a reduction from current light duty vehicle and truck evaporative emission levels that accepting the real risk of not being able to implement a 6 g/test standard for 1978, due to the additional time necessary to thoroughly study and evaluate the technical feasibility, relationship between a 2 g/test standard and background emission levels, cost and lead time associated with the 2 gram level, is not justified. Therefore, in order to allow implementation of the revised test procedure and the 6 g/test standard for 1978, the originally proposed regulatory action has been divided into two separate rulemaking actions. The revised test procedure and 1978 standard are being promulgated at this time. The final rulemaking for a longer term evaporative emission standard is presently being considered by the Agency. The 1978 standard will remain in effect for subsequent model years until revised.

Fuel evaporative hydrocarbon emissions have been studied and measured since 1958. Federal control of evaporative emission levels was first proposed in the FEDERAL REGISTER (32 FR 2448) in 1967 when a novel and relatively untried measurement procedure, the use of a vehicle enclosure, was proposed. These rules would have become effective for the 1969 model year. Final rulemaking published in 1968 (33 FR 8304) abandoned the vehicle enclosure measurement procedure in favor of a better known procedure (carbon trap method) which utilizes the adsorption of hydrocarbon on activated charcoal that is weighed before and after the test to determine the mass of hydrocarbon adsorbed. Because of manufacturing lead time requirements, the implementation of the standards was delayed until the 1971 model year, and the emission level was set at 6 g/test. The evaporative emission standard was reduced to a 2 g/test for 1972 and subsequent model years.

The current carbon trap method for measuring evaporative emissions has been found through testing with a more accurate measurement method to greatly underestimate actual evaporative emissions. The more accurate testing method is the Society of Automotive Engineers (SAE) recommended procedure for measuring evaporative emissions (SAE J171a) and involves collecting the evaporative emissions in a large sealed enclosure containing the test vehicle. Results from the 1972 EPA surveillance test program (as reported in Supplement No. 5 of AP–42) of "controlled" in-use vehicles indicate an average emisison level of about 24 g/test by the vehicle enclosure method, more than 12 times the current standard established for the carbon trap method. Thus, the amount of control thought to exist for evaporative emissions does not in actuality exist. Therefore, revised regulations are being implemented to reduce this major source of hydrocarbon air pollution.

The most significant change in the regulations is the revised evaporative emission test procedure which applies to both light duty vehicles and light duty trucks. The standard 6 g/test is established for the 1978 model year which appears to be higher than the present 2 g/test standard as measured by the "carbon trap method." However, when the 6 g/test standard is required to be met by the new test procedure, evaporative hydrocarbons emissions will be reduced from about 1.76 g/mile to 0.6 g/mile. This action will reduce nationwide hydrocarbon emissions from all mobile sources by as much as 46 percent by the year 1990. For certain Air Quality Control Regions that are expected to have difficulty meeting the ambient air quality standards for oxidants, this action will reduce hydrocarbon emissions from all sources by 7.8 percent by the year 1985.

It is estimated that the increased retail cost to the consumer will average about $7.30 for control system components to meet the new evaporative emission standard. No lifetime costs due to increased fuel consumption or maintenance are expected. It is estimated that the major impact on industry will be due to any decrease in sales resulting from this action; however, this is expected to be less than 0.16%. The cost of certification over the next five years that the manufacturers must bear is expected to increase by $2.2 million. The government's cost increase over the same five year period is expected to be $0.4 million. The total national capital investment over the first five years is estimated to total $530 million. This compares to a projected $230 billion in retail sales of new cars and light duty trucks during the same time period, i.e., 1978–1982.

The revised standard and procedure will provide improved air quality at a cost of about $50 per ton of hydrocarbon removed. As a comparison, the cost-effectiveness of reducing automotive exhaust hydrocarbon emissions from the current standard (1.5 g/mile) to the statutory standard (0.41 g/mile) is between $500 and $1400 per ton of hydrocarbon removed. This additional control of evaporative emissions is one of the more cost effective strategies available for reducing hydrocarbon emissions.

Comments on the NPRM were received from many motor vehicle manufacturers and from several other interested parties. All of the comments were analyzed and considered in the preparation of the final rulemaking. The major issues have been summarized here. For the minor technical issues, only the changes to the procedure will be identified. A complete analysis of comments on all issues has been prepared and is available for public review.

On July 18, 1975, the Environmental Protection Agency (EPA) published a decision in the FEDERAL REGISTER (40 FR 30311) which granted the State of California a waiver of Federal preemption under section 209(b) of the Clean Air Act to enable California to enforce an evaporative emission standard for 1977 and subsequent model year light duty vehicles and light duty trucks of 6 g/test as measured by the vehicle enclosure method. The decision granted the waiver to the extent that a Federal standard of equal or greater stringency was not subsequently established. At the same time, EPA announced that all reasonable efforts would be made to establish a more stringent Federal evaporative emission standard based on the vehicle enclosure measurement method. Since the Federal standard hereby published is of equal stringency to the 1978 California standard, the waiver granted to California on July 18, 1975, will no longer be in effect as of the date these Federal standards become effective.

MAJOR ISSUES

Feasibility and lead time requirements of a 6 g/test standard. Most manufacturers responded that a 6 g/test standard, measured by the proposed procedure, is feasible and desirable. Some stated that a delay until 1979 in the implementation of the standard would be more desirable. The consensus of opinion though, is that implementation for 1978 is achievable, although lead time constraints may present some problems.

Cost of a 6 g/test standard. The manufacturers estimated costs to the consumer that range from $1 to $15 per vehicle depending upon the control technique chosen. The sales weighted average of the manufacturers' cost estimates is $7.40 which is essentially the same as the value used in the draft economic impact statement ($7.30). An independent study performed by Exxon Research and Engineering Company for EPA indicated that costs of only about $2 per vehicle are possible. This indicates that the EPA estimate of $7.30 is conservative, and may be high.

Evaporative family concept for certification. The purpose of developing an evaporative family concept was to require evaporative emission testing of only those exhaust test vehicles which represent unique evaporative control systems. This would result in a reduction in the

required test load. Those manufacturers who understood the proposal agreed that the test load would be reduced and favored the proposal. Others thought that evaporative test vehicles would be added to the exhaust test vehicles thus increasing the test fleet and therefore the test load. Modifications have been made to the regulations to clarify the requirements in this regard.

Durability and evaporative system deterioration. Most manufacturers suggested that durability testing should not be required. Some commented that EPA must demonstrate the need for durability testing before it can be required. Others contended that no durability data exist, that they can not be obtained for 1978, and that component life testing is sufficient demonstration of system durability. Others said that existing data demonstrate that systems do not deteriorate. The data presented do show that at least some systems deteriorate. The EPA is required, under the provisions of section 206(a)(1), to make a determination that a control system to be installed on vehicles will be effective for the useful life of the vehicle, prior to issuing a Certificate of Conformity for such vehicle. Useful Life has been defined as 50,000 miles. For exhaust emission control system evaluation, the testing protocols include the operation of a limited number of test vehicles over a defined 50,000 mile run. The 50,000 miles are usually accumulated during a 3 month period. However, there are technical reasons for believing that the durability of evaporative emission control systems may be more significantly affected by time than by mileage; extensive use of plastic-like materials is expected to be made to seal possible sources of evaporative emissions, and such materials tend to deteriorate as a function of time, rather than miles. Thus there is considerable question about the validity of utilizing the 50,000 mile test as a basis for evaluating the durability of evaporative emission control systems.

The EPA is currently unable to specify a single test protocol that would be applicable to all vehicles that could be demonstrated to be a valid test of the durability of evaporative emission control systems. Thus, for the purpose of satisfying the requirement that the EPA evaluate the durability of evaporative emission control systems, as well as for the purpose of generating data on alternative test protocols some of which may have industry-wide applicability, the regulations require that each manufacturer specify in his Part I application the test procedures that he intends to utilize to evaluate the durability of his evaporative emission control system and to develop a Deterioration Factor for such systems. The data from these test programs, and the derived Deterioration Factor, are required to be submitted with the Part II Application. From the data thus submitted the EPA expects, for some subsequent model year, to be able to promulgate a standardized durability testing protocol that will apply on an industry-wide basis.

Need for evaporative regulations. Some manufacturers contended that the value from the 1973 EPA surveillance test program cited in the NPRM was the result of a defective test procedure and that the actual values are much lower. EPA has investigated the test procedures used in the study in question and finds that the tests were conducted properly. Due to the computational errors, however, it has been determined that the average value should have been 26.5 g/test rather than 31 g/test as reported in the NPRM.

The value used in the economic impact statement was based on the results of the 1972 surveillance study which showed emissions to be at a 24 g/test level (1.76 g/mi equivalent). The 24 g/test level has undergone the scrutiny required to be incorporated as a part of the Compilation of Air Pollutant Emission factors, AP-42 (Supplement No. 5). The results from the 1973 surveillance program have not yet undergone such scrutiny and therefore were not used.

Background emissions. EPA originally proposed to include non-fuel evaporative hydrocarbon (background) emissions in the evaporative emission measurement and expected manufacturers to provide test vehicles with stabilized background emissions. Manufacturers responded that they sometimes use brand new cars (less than 60–90 days old) which do not have stabilized background emissions. The manufacturers did not address whether artificial aging of new vehicles or obtaining aged vehicles from other sources would be viable solutions to the problem. EPA analysis indicates that both of these are viable options for assuring stabilized background emission levels. At least one study has shown that new car background emissions can be reduced quickly by baking the car for several hours which is not prohibited under the current regulations. Regarding alternative sources of aged vehicles, manufacturers already have the option to rebuild existing vehicles into certification vehicles. Therefore vehicles can be obtained from a variety of sources, and rebuilt into certification vehicles. EPA will place no restrictions on the manufacturers' ability to provide test vehicles with stabilized background emissions.

In addition, manufacturers have a number of options available to them to minimize background emissions that come from new paint, from plastic in the interior of vehicles, from newly manufactured tires, and from road oil and oil drippings on the engine. The regulations do not require test cars to be painted, to contain plastic headliners or seatcovers, or to be equipped with recently-manufactured tires; the regulations do not prohibit the steam cleaning of cars prior to emission testing. Inasmuch as manufacturers typically take advantage of every possible regulatory provision to minimize measured emissions on test vehicles, it is reasonable to expect manufacturers to do everything that they may legally do to minimize background evaporative emissions from their test vehicles. Providing a factor to account for possible background emissions (e.g., 1 g/test) would thus have the practical effect of easing the intended fuel evaporative emission standard by whatever the background allowance might be since manufacturers would still be expected to provide test vehicles with minimized background emissions. For that reason, the proposal of several manufacturers to provide an allowance for background emissions has not been adopted.

EPA is aware of the fact that the options available to the manufacturer to reduce background emissions from prototype vehicles used in certification testing are not available when vehicles may be tested in in-use vehicle emission surveillance programs, or on the assembly line. As regards in-use vehicles, such vehicles would not normally be tested by EPA before they are a year or more older, at which time background emissions can reasonably be expected to have stabilized and be minimal. If, however, a manufacturer uses paints or plastic materials that will continue for long periods of time to emit significant levels of background emissions, these emissions should properly be charged against the in-use vehicle inasmuch as such emissions are real hydrocarbons that contribute to air pollution. Thus, for in-use vehicles the only additional preconditioning that would be undertaken would be removal of spilled or leaked oil, and miscellaneous deposits of road oils.

As regards assembly-line testing, the Agency recognizes that newly assembled vehicles may have high background emissions unrepresentative of typical in-use background emissions. Thus, testing of such vehicles is expected to utilize analytical procedures, yet to be specified, which enable fuel evaporative emissions to be distinguished from emissions from non-fuel sources.

Test Procedure Changes

The amount of fuel for preconditioning is changed from 2 gallons (as proposed in the NPRM) to 40 percent of nominal tank capacity to prevent abnormal loading of the evaporative control system.

The diurnal test has been modified to require installation of the fuel cap when the fuel temperature reaches 60±2° F instead of immediately after fueling as proposed. This test procedure change will eliminate unrepresentative loading of the evaporative control system. This change requires that capping take place in the enclosure with the purge blowers operating.

The diurnal test has also been modified to allow artificial heating of the fuel tank(s) to bring the liquid fuel up to the prescribed starting temperature. The prescribed initial fuel temperature specification has been broadened from the proposed 60±1° F to 60±2° F. The temperature rise has been changed to a 24±1° F temperature rise (above the initial fuel temperature) instead of the proposed 60±1° F to 84±1° F temperature rise. Also, the temperature control limits during the diurnal have been broadened from ±2° F to ±3° F. These modifications should improve test repeatability

and provide a more practical test procedure.

Because of the changes to the diurnal test, the proposed requirement to use type T thermocouples is no longer necessary. Therefore, the type J thermocouples currently used can continue to be used without decreased accuracy.

Data show that vehicle idle times of up to 7 minutes have no effect on hot soak emissions. Time between the exhaust and the hot soak tests is changed from a total of 5 minutes, with no more than 1 minute of engine off time to a total of 7 minutes with no more than 2 minutes of engine off time.

The proposed regulations did not specify the exact amount of mixing required or specific fan location. The air circulation is now specified as not less than 200 cfm nor more than 1000 cfm. Multiple fans may be used, but the air stream(s) may not be directed toward the vehicle.

The proposed regulations did not specify the amount of propane to be used for the enclosure calibration. A nominal amount of propane (4g) is given as a convenient quantity for the enclosure calibration in the final regulations. Also, the criteria for an acceptable retention check have been changed. The final value (after 4 hours) may not differ by more than 4 percent of the initial value.

Enclosure background measurements need only be made after maintenance which can be expected to affect enclosure background levels rather than after any maintenance.

The proposed calculation of evaporative emissions required the use of a nominal value of 50 ft^3 for the volume of the vehicle. The final regulations add the option of allowing a manufacturer to measure the actual vehicle volume for all of his test vehicles.

These regulations do not change the requirement for evaporative emission testing at high altitude.

One further modification to the test procedures may be included in future rulemaking (expected to apply with the implementation of the longer term evaporative emission standard), but due to lead time requirements to develop such procedures is not included as a part of the 1978 regulations. This modification will be to place controls on the tank vapor temperature during the diurnal test to insure that the temperature rise in the vapor space is representative of actual use, since the vapor temperature rise is the principal driving force for diurnal emissions and recent data indicate that, although the liquid fuel temperature rises 24° F, the vapor temperature may rise only 12° to 14° F.

The proposed regulations reorganized Subpart B to promote clarity. Subpart B is further modified in the final regulations by the insertion of reserved sections for possible future expansion of the regulations.

The new numbering system that was proposed for Subpart B is adopted. The model year designation appears as a suffix following the section number and is separated by a hyphen. A section will remain effective until it is superseded. This change will make republishing for each model year unnecessary. Also, when a section is amended for an upcoming model year it will appear following the current section. This will enable the reader to quickly find the changes that have been made.

Comments which were received in response to the NPRM, EPA's analysis of the comments, and the Final Environmental Impact Statement are available for inspection and copying during normal business hours at the U.S. Environmental Protection Agency, Public Information Reference Unit, Room 2922 (EPA Library), 401 M Street, SW., Washington, D.C. 20460. As provided in 40 CFR Part 2, a reasonable fee may be charged for copying services.

Single copies of the Final Environmental Impact Statement for this regulation are available in limited number upon request from the Public Information Center (PM–215), U.S. Environmental Protection Agency, Washington, D.C. 20460.

This notice of final rulemaking is issued under authority of sections 202, 206, 207, 208, and 301(a) of the Clean Air Act, as amended (42 U.S.C. 1857f–1, 1857f–5, 1957f–5a, 1857f–6, and 1857g(a)).

It is hereby certified that the economic and inflationary impacts of this regulation have been carefully evaluated in accordance with Executive Order 11821.

Effective date: This revision of Part 86 becomes effective on September 22, 1976.

Dated: August 12, 1976.

RUSSELL E. TRAIN,
Administrator.

Part 86 of Chapter I, Title 40 of the Code of Federal Regulations is amended by revising Subparts A and B as follows:

Subpart A—General Provisions for Emission Regulations for 1977 and Later Model Year New Light Duty Vehicles, 1977 and Later Model Year New Light Duty Trucks and for 1977 and Later Model New Heavy Duty Engines

1. A new § 86.078–2 is added and reads as follows:

§ 86.078–2 Definitions.

The following definitions apply beginning with the 1978 model year. Section 86.077–2 remains effective excepting those definitions which are hereby superseded.

"Accuracy" means the difference between a measurement and true value.

"Basic Engine" means a unique combination of manufacturer, engine displacement, number of cylinders, fuel system (as distinguished by number of carburetor barrels or use of fuel injection), catalyst usage, and other engine and emission control system characteristics specified by the Administrator.

"Body Type" means a name denoting a group of vehicles that are either in the same car line or in different car lines provided the only reason the vehicles qualify to be considered in different car lines is that they are produced by separate divisions of a single manufacturer.

"Calibration" means the set of specifications, including tolerances, unique to a particular design, version, or application of a component or component assembly capable of functionally describing its operation over its working range.

"Car line" means a name denoting a group of vehicles within a make or car division which has a degree of commonality in construction (e.g., body, chassis). Car line does not consider any level of decor or opulence and is not generally distinguished by characteristics as roof line, number of doors, seats or windows except for station wagons or light duty trucks. Station wagons and light duty trucks are considered to be different car lines than passenger cars.

"Diurnal breathing losses" means evaporative emissions as a result of the daily range in temperature.

"Engine Code" means a unique combination, within an engine system combination, of displacement, carburetor (or fuel injection) calibration, choke calibration, distributor calibration, auxiliary emission control devices and other engine and emission control system components specified by the Administrator.

"Engine—system combination" means an engine family-exhaust emission control system combination.

"Evaporative emission code" means a unique combination in an evaporative emission family—evaporative emission control system combination, of purge system calibrations, fuel tank and carburetor bowl vent calibrations and other fuel system and evaporative emission control system components and calibrations specified by the Administrator.

"Evaporative emissions" means hydrocarbons emitted into the atmosphere from a motor vehicle, other than exhaust and crankcase emissions.

"Evaporative vehicle configuration" means a unique combination of basic engine, engine code, body type, and evaporative emission code.

"Fuel system" means the combination of fuel tank(s), fuel pump, fuel lines, and carburetor or fuel injection components, and includes all fuel system vents and fuel evaporative emission control system components.

"Hot soak losses" means evaporative emissions after termination of engine operation.

"Malfunction" means not operating according to specifications listed in the application for certification.

"Model Type" means a unique combination of car line, basic engine, and transmission class.

"Nominal Fuel Tank Capacity" means the volume of the fuel tank(s), specified by the manufacturer to the nearest tenth of a U.S. gallon, which may be filled with fuel from the fuel tank filler inlet.

"Precision" means the standard deviation of replicated measurements.

"Tank fuel volume" means the volume of fuel in the fuel tank(s), which is determined by taking the manufacturer's nominal tank(s) capacity and multiplying by 0.40, the result being rounded using ASTM E29–67 to the nearest tenth of a U.S. gallon.

"Transmission Class" means the basic type of transmission, e.g., manual, automatic, semi-automatic.

"Transmission Configuration" means a unique combination, within a transmission class, of the number of the forward gears and, if applicable, overdrive. The Administrator may further subdivide a transmission configuration (based on such criteria as gear ratios, torque convertor, multiplication ratio, stall speed and shift calibration, etc.), if he determines that significant fuel economy or exhaust emission differences exist within that transmission configuration.

"Vehicle configuration" means a unique combination of basic engine, engine code, inertia weight, transmission configuraton, axle ratio.

"Zero (0) Miles" means that point after initial engine starting (not to exceed 10 miles of vehicle operation, or one hour of engine operation) at which normal assembly line operations adjustments are completed.

2. A new § 86.078–3 is added and reads as follows:

§ 86.078–3 Abbreviations.

(a) The abbreviations in this section apply to this subpart and also to Subparts B, H, I and J of this part.

(b) The abbreviations used in this subpart have the following meanings in both capital and lower case:

AECD—Auxiliary Emission Control Device.
API—American Petroleum Institute.
ASTM—American Society for Testing and Materials.
BHP—Brake horsepower.
BSCO—Brake specific carbon monoxide.
BSHC—Brake specific hydrocarbons.
BSNOx—Brake specific oxides of nitrogen.
C—Celsius.
cfh—Cubic feet per hour.
CFV—Critical flow venturi.
CL—Chemiluminescence.
CO_2—Carbon dioxide.
CO—Carbon monoxide.
Conc.—Concentration.
cfm—Cubic feet per minute.
CT—Closed Throttle.
cu. in.—Cubic inch(es).
CVS—Constant volume sampler.
EP—End point.
Evap.—Evaporated.
F—Fahrenheit.
FID—Flame ionization detector.
ft.—Feet.
FL—Full load.
gal.—U.S. gallon(s).
g—Grams.
GVW—Gross Vehicle Weight.
H_2O—Water.
HC—Hydrocarbon(s).
HFID—Heated flame ionization detector.
Hg—Mercury.
Hi.—High.
Hp—Horsepower.
Hr—Hour.
IBP—Initial boiling point.
ID—Internal diameter.
in.—Inches.
km/h—kilometers per hour.
kPa—Kilopascal(s).
Lb—Pound(s).
LFE—Laminar flow element.
Lb-ft—Pound-feet.
m—Metre.
Max.—Maximum.
Min.—Minimum.
Min.—Minute(s).
ml—Milliliter(s).
mph—Miles per hour.
mm—Millimeter(s).
mv—Millivolt(s).
N_2—Nitrogen.
NDIR—Nondispersive infrared.
NO—Nitric oxide.
NO_2—Nitrogen dioxide.
NOx—Oxides of nitrogen.
No.—Number.
Pb—Lead.
PDP—Positive displacement pump.
ppm—Parts per million by volume.
ppm C—Parts per million, carbon.
psi—Pounds per square inch.

3. A new § 86.078–8 is added and reads as follows:

§ 86.078–8 Emission standards for 1978 light duty vehicles.

(a) (See paragraph (a) of § 86.077–8)

(b)(1) Evaporative emissions from gasoline fueled light duty vehicles shall not exceed:

(i) *Hydrocarbons.* 6.0 grams per test.

(2) The standard set forth in paragraph (b)(1) of this section refers to a composite sample of the evaporative emissions collected under the conditions set forth in Subpart B of this part and measured in accordance with those procedures.

(c) (See paragraph (c) of § 86.077–8)

4. A new § 86.078–9 is added and reads as follows:

§ 86.078–9 Emission standards for 1978 light duty trucks.

(a) (See paragraph (a) of § 86.077–9)

(b)(1) Evaporative emissions from 1978 model year gasoline fueled light duty trucks shall not exceed:

(i) *Hydrocarbons.* 6.0 grams per test.

(2) The standard set forth in paragraph (b)(1) of this section refers to a composite sample of the evaporative emissions collected under the conditions set forth in Subpart B of this part and measured in accordance with those procedures.

(c) (See paragraph (c) of § 86.077–9)

5. A new § 86.078–21 is added and reads as follows:

§ 86.078–21 Application for certification.

(a) through (b)(3) (See paragraphs (a) through (b)(3) of § 86.077–21)

(4)(i) A description of the proposed mileage (or service) accumulation procedure for durability testing.

(ii) A description of the test procedures to be used to establish the evaporative emission deterioration factors required to be determined and supplied in § 86.077–23(a)(2).

(b)(5) through (c) (See paragraphs (b)(5) through (c) of § 86.077–21)

6. A new § 86.078–22 is added and reads as follows:

§ 86.078–22 Approval of application for certification test fleet selections.

(a) through (c) (See paragraphs (a) through (c) of § 86.077–22)

(d) The Administrator does not approve the test procedures for establishing the evaporative emission deterioration factors. The manufacturer shall submit the procedures as required in § 86.078–21(b)(4)(ii) prior to the Administrator's selection of the test fleet under § 86.078–24(b)(1) and if such procedures will involve testing of durability data vehicles selected by the Administrator or elected by the manufacturer under § 86.078–24(c)(1), prior to initiation of such testing.

7. A new § 86.078–23 is added and reads as follows:

§ 86.078–23 Required data.

The manufacturer shall perform the tests required by the applicable test procedures, and submit to the Administrator the following information:

(a)(1) Exhaust emission durability data on such vehicles (or engines) tested in accordance with applicable test procedures and in such numbers as specified, which will show the performance of the systems installed on or incorporated in the vehicle (or engine) for extended mileage (or extended operation), as well as a record of all pertinent maintenance (all maintenance and servicing for diesel heavy duty engines) performed on the test vehicles (or test engines).

(2) Evaporative emission deterioration factors for each evaporative emission family—evaporative emission control system combination and all test data, that are derived from testing described under § 86.078–21(b)(4)(ii) designed and conducted in accordance with good engineering practice to assure that the vehicles covered by a certificate issued under § 86.078–30 will meet the evaporative emission standards in § 86.078–8 for the useful life of the vehicle.

(b)(1)(i) (See paragraph (b)(1)(i) of § 86.077–23).

(ii) Emission data on those vehicles selected under §§ 86.078–24(b)(1)(v) and 86.078–24(b)(1)(vii)(D) and tested in accordance with the applicable test procedures of this subpart and in such numbers as therein specified, which shall be tested at zero kilometers (zero miles) at any altitude, and under high altitude conditions after 6436 kilometers (4000 miles) of operation at any altitude.

(b)(2) through (d)(2) (See paragraphs (b)(2) through (d)(2) of § 86.077–23)

(3) For evaporative emission durability, a statement of compliance with paragraph (a)(2) of this section.

8. A new § 86.078–24 is added and reads as follows:

§ 86.078–24 Test vehicles and engines.

(a)(1) through (a)(4) (See paragraphs (a)(1) through (a)(4) of § 86.077–24)

(5) The gasoline fueled vehicles covered by an application for certification will be divided into groupings which are expected to have similar evaporative emission characteristics throughout their useful life. Each group of vehicles with similar evaporative emission characteristics shall be defined as a separate evaporative emission family.

(6) To be classed in the same evaporative emission family, vehicles must be identical in all of the following respects:

(i) Vapor storage device (e.g., canister, air cleaner, crankcase, induction system).

(ii) Basic canister design.

(iii) Fuel system.

(7) Where vehicles are of a type which cannot be divided into evaporative emission families based on the criteria listed above, the Administrator will establish families for those vehicles based upon the features most related to their evaporative emission characteristics.

(b)(1)(i) (See paragraph (b)(1)(i) of § 86.077–24).

(ii) Vehicles of each engine family will be divided into engine displacement-exhaust emission control system combinations as applicable. A projected sales volume will be established for each combination for the model year for which certification is sought. One vehicle of each combination will be selected in order of decreasing projected sales volume until 70 percent of the projected sales of a manufacturer's total production of vehicles of that engine family is represented, or until a maximum of four vehicles is selected. If any single combination represents over 70 percent, then two vehicles of that combination may be selected. The vehicle selected for each combination will be specified by the Administrator as to such features as engine code, transmission type, fuel system, and inertia weight class.

(iii) through (v) (See paragraphs (b)(1)(iii) through (b)(1)(v) of § 86.077–24).

(vi) The Administrator may combine testing requirements for any vehicle selected under paragraph (b)(1)(v) or (b)(1)(vii)(D) of this section with the testing requirements for any similar vehicle in the same engine-system combination selected under paragraph (b)(1)(ii), (iii), or (iv) of this section or any similar vehicle in the same engine-system, evaporative emission family, evaporative emission control system combination selected under (b)(1)(vii) (A) or (B) of this section. The testing requirements may be combined by the Administrator requiring a vehicle selected for testing under paragraphs (b)(1)(ii), (iii), (iv), (vii)(A), or (vii)(B) of this section to be modified (if necessary) after mileage accumulation and emission testing for the purpose of demonstrating compliance with § 86.078–23(b)(1)(ii).

(vii)(A) Vehicles of each evaporative emission family will be divided into evaporative emission control systems. One vehicle of each evaporative emission control system within the evaporative emission family will be selected.

(B) The Administrator may select a maximum of four (4) additional vehicles within each evaporative emission family based upon features indicating that they may have the highest evaporative emission levels of vehicles in that family.

(C) The Administrator may determine that the vehicles selected under paragraphs (b)(1)(i) through (vi) of this section may be used to satisfy the requirements of paragraphs (b)(1)(vii)(A) and (B) of this section.

(D) The Administrator will also select one vehicle for each evaporative emission control system within each evaporative family for which vehicles are to be sold at high altitude.

(E) Vehicles selected under paragraph (b)(1)(v) of this section may be used to satisfy the requirements of paragraph (b)(1)(vii)(D) of this section.

(b)(2) through (g) (See paragraphs (b)(2) through (g) of § 86.077–241).

9. A new § 86.078–25 is added and reads as follows:

§ 86.078–25 Maintenance.

(a)(1) (See paragraph (a)(1) of § 86.077–25).

(a)(2)(i) Scheduled maintenance on the engine, emission control system, and fuel system of durability vehicles, selected by the Administrator or elected by the manufacturer under § 86.078–24(c)(1), shall be scheduled for performance during durability testing at the same mileage intervals that will be specified in the manufacturer's maintenance instructions furnished to the ultimate purchaser of the motor vehicle. Such maintenance shall be performed, except as provided in paragraph (a)(6)(iii) of this section, only under the following provisions.

(a)(2)(i)(A) through (a)(2)(v)(A)(1) (See paragraphs (a)(2)(i)(A) through (a)(2)(v)(1) of § 86.077–25).

(2) Has made a determination that the need for maintenance or repairs is indicated by an overt indication of malfunction such as persistent misfire, vehicle stall, overheating, fluid leakage, loss of oil pressure, or charge indicator warning. For the evaporative system, this overt indication may be indicated by such items as fuel odor or fluid leakage.

(a)(2)(v)(B) through (a)(3)(i) (See paragraphs (a)(2)(v)(B) through (a)(3)(i) of § 86.077–25).

(a)(3)(ii) Maintenance on Emission data vehicles selected under § 86.078–24(b)(1)(v) or 24(b)(1)(vii)(D) and permitted to be tested for purposes of § 86.078–23(b)(1)(ii) under the provisions of § 86.078–24(b)(1)(vi) may be performed in conjunction with emission control system modifications at the 6436 kilometer (4000 mile) test point, and shall be performed in accordance with the maintenance instructions to be provided to the ultimate purchaser required under § 86.077–38.

(a)(3)(iii) through (d) (See paragraphs (a)(3)(iii) through (d) of § 86.077–25)

10. A new § 86.078–26 is added and reads as follows:

§ 86.078–26 Mileage and service accumulation; emission measurements.

(a)(1) and (a)(2) (See paragraphs (a)(1) and (a)(2) of § 86.077–26)

(3) Emission data vehicles.

(i) Gasoline-fueled.

(A) Each gasoline-fueled emission data vehicle shall be driven 4000 miles with all emission control systems installed and operating. Complete exhaust emission tests shall be conducted at zero miles and 4000 miles on those vehicles selected under § 86.178–24(b)(1)(i) through (b)(1)(vi). Complete evaporative emission tests shall be conducted at 4000 miles on those vehicles selected under § 86.078–24(b)(1)(vii). The manufacturer may at his option test the vehicles selected under § 86.078–24(b)(1)(vii) up to three times at the 4000 mile test point as long as the ±250 mile test tolerance is adhered to. The Administrator may determine under § 86.078–24(f) that no testing is required.

(B) The emission data vehicle(s) selected for testing under § 86.078–24(b)(1)(v) or (b)(1)(vii)(D) shall be driven 6436 kilometers (4000 miles) at any altitude. Emission tests shall be conducted at zero kilometers (zero miles) at any altitude and 6436 kilometers (4000 miles) under high altitude conditions.

(C) The emission data vehicle(s) selected for testing under § 86.078–24(b)(1)(v) or (b)(1)(vii)(D) and permitted to be tested for purposes of § 86.078–23(b)(1)(ii) under the provisions of § 86.078–24(b)(1)(vi) shall be driven 6436 kilometers (4000 miles) at low altitude. Emission tests shall be conducted at zero kilometers (zero miles) at low altitude and 6436 kilometers (4000 miles) under both low and high altitude conditions. For the purposes of this subparagraph, low altitude means any elevation less than 549 meters (1800 feet).

(a)(3)(ii) through (a)(3)(ii)(C) (See paragraphs (a)(3)(ii) through (a)(3)(ii)(C) of § 86.077–26)

(4) Durability data vehicles

(i) *Gasoline Fueled.* Each gasoline fueled durability data vehicle selected by the Administrator or elected by the manufacturer under § 86.078–24(c)(1) shall be driven, with all emission control systems installed and operating for 50,000 miles or such lesser distance as the Administrator may agree to as meeting the objective of this procedure. Complete exhaust emission tests shall be made on all durability data vehicles selected by the Administrator or elected by the manufacturer under § 86.078–24(c) at the following mileage points: 0; 5000; 10,000; 15,000; 20,000; 25,000; 30,000; 35,000; 40,000; 45,000; 50,000. The Administrator may determine under § 86.078–24(f) that no testing is required.

(a)(4)(ii) through (a)(10) (See paragraphs (a)(4)(ii) through (a)(10) of § 86.077–26)

(a)(11) This section does not apply to testing conducted to meet the requirements of § 86.078–23(a)(2).

(b) through (c) (see paragraphs (b) through (c) of § 86.077–26)

11. A new § 86.078–28 is added and reads as follows:

§ 86.078–28 Compliance with emission standards.

(a)(1) through (a)(3) (see paragraphs (a)(1) through (a)(3) of § 86.077–28)

(4) The procedure for determining compliance of a new motor vehicle with exhaust emission standards is as follows:

(i) Separate emission deterioration factors shall be determined from the exhaust emission results of the durability data vehicle(s) for each engine-system condition. A separate factor shall be established for exhaust HC, exhaust CO, and exhaust NOx for each engine system combination. A separate evaporative emission deterioration factor shall be determined for each evaporative emission family-evaporative emission control system combination from the testing conducted by the manufacturer.

(A) The applicable results to be used in determining the exhaust emission deterioration factors for each engine-system combination shall be:

(1) All valid exhaust emission data from the tests required under § 86.078–26(a)(4), except the zero mile tests. This shall include the official test results, as determined in § 86.078–29 for all tests conducted on all durability data vehicles of the combination selected under § 86.078–24(c) (including all vehicles elected to be operated by the manufacturer under § 86.078–24(c)(1)(ii)).

(2) All exhaust emission data from the tests conducted before and after the scheduled maintenance provided in § 86.078–25(a).

(3) All exhaust emission data from tests required by maintenance approved under § 86.078–25, in those cases where the Administrator conditioned his approval for the performance of such maintenance on the inclusion of such data in the deterioration factor calculation.

(B) All applicable exhaust emission results shall be plotted as a function of the mileage on the system, rounded to the nearest mile, and the best fit straight lines, fitted by the method of least squares, shall be drawn through all these data points. The interpolated 4,000- and 50,000-mile points on this line must be within the standards provided in § 86.078–8 or § 86.078–9, as applicable, or the data will not be acceptable for use in calculation of a deterioration factor, unless no applicable data point exceeded the standard. An exhaust emission deterioration factor shall be calculated for each engine-system combination as follows:

factor=Exhaust emissions interpolated to 50,000 miles/exhaust emission interpolated to 4,000 miles.

These interpolated values shall be carried out to a minimum of four places to the right of the decimal point before dividing one by the other to determine the deterioration factor. The results shall be rounded to three places to the right of the decimal point in accordance with ASTM E 29–67.

(C) An evaporative emissions deterioration factor shall be determined from the testing conducted as described in § 86.078–21(b)(4)(ii), for each evaporative emission family-evaporative emission control system combination to indicate the evaporative emission level at 50,000 miles relative to the evaporative emission level at 4,000 miles as follows:

factor=Evaporative emission level at 50,000 miles *minus* the evaporative emission level at 4,000 miles.

The factor shall be established to a minimum of two places to the right of the decimal.

(ii)(A) The official exhaust emission test results for each emission data vehicle at the 4000 mile test point shall be multiplied by the appropriate deterioration factor: *Provided,* That if a deterioration factor as computed in paragraph (a)(4)(i)(B) of this section is less than one, that deterioration factor shall be one for the purposes of this paragraph.

(B) The official evaporative emission test results for each evaporative emission data vehicle at the 4000 mile test point shall be adjusted by addition of the appropriate deterioration factor: *Provided,* That if a deterioration factor as computed in paragraph (a)(4)(i)(c) of this section is less than zero, that deterioration factor shall be zero for the purposes of this paragraph.

(a)(4)(iii) (See paragraph (a)(4)(iii) of § 86.077–28)

(iv) Every test vehicle of an engine family must comply with the exhaust emission standards, as determined in paragraph (a)(4)(iii) of this section, before any vehicle in that family may be certified.

(v) Every test vehicle of an evaporative emission family must comply with the evaporative emission standards, as determined in paragraph (a)(4)(iii) of this section, before any vehicle in that family may be certified.

(b) through (c) (See paragraphs (b) through (c) of § 86.077–28)

12. A new § 86.078–29 is added and reads as follows:

§ 86.078–29 Testing by the Administrator.

(a)(1) through (a)(3)(i) (See paragraphs (a)(1) through (a)(3)(i) of § 86.077–29)

(ii) Whenever the Administrator does not conduct a test on a test vehicle at a test point, the manufacturer's test data will be accepted as the official data for that test point: *Provided,* That if the Administrator makes a determination based on testing under paragraph (a)(2) of this section, that there is a lack of correlation between the manufacturer's test equipment and the test equipment used by the Administrator, no manufacturer's test data will be accepted for purposes of certification until the reasons for the lack of correlation are determined and the validity of the data is established by the manufacturer, and further provided, that if the Administrator has reasonable basis to believe that any test data submitted by the manufacturer is not accurate or has been obtained in violation of any provisions of this part, the Administrator may refuse to accept that data as the official data pending retesting or submission or further information. If the manufacturer conducts more than one test on a vehicle, as authorized under § 86.078–26(a)(3)(i)(A), the data from the last test in that series of tests on that vehicle, will constitute the official data.

(a)(3)(iii)(A) (See paragraph (a)(3)(iii)(A) of § 86.077–29)

(B) If the Administrator determines that the test data developed on an emission data vehicle under paragraph (a)(3)(i) of this section would cause that vehicle to fail due to excessive 4000 mile emissions or by application of the appropriate deterioration factor, then the following procedure shall be observed:

(a)(3)(iii)(B)(1) through (b) (See paragraphs (a)(3)(iii)(B)(1) through (b) of § 86.077–29)

13. A new § 86.078–30 is added and reads as follows:

§ 86.078–30 Certification.

(a)(1) and (a)(2) (See paragraphs (a)(1) and (a)(2) of § 86.077–30)

(3) One such certificate will be issued for each engine family—evaporative family combination and will certify compliance with no more than one set of applicable standards.

(a)(4) through (a)(7) (See paragraphs (a)(4) through (a)(7) of § 86.077–30)

(b)(1) The Administrator will determine whether a vehicle (or engine) covered by the application complies with applicable standards by observing the following relationships:

(i) Light duty vehicles and light duty trucks.

(A) The durability data vehicle(s) selected under § 86.078–24(c)(1)(i) shall represent all vehicles of the same engine-system combination.

(B) The emission data vehicle(s) selected under § 86.078–24(b)(1)(ii), (b)(1)(iii), and (b)(1)(iv) shall represent all vehicles of the same engine-system combination as applicable to be sold below 4000 ft.

(C) The emission data vehicle(s) selected under § 86.078–24(b)(1)(vii)(A) and (b)(i)(vii)(B) shall represent all vehicles of the same evaporative control system within the evaporative family, as applicable, to be sold below 4000 ft.

(D) The emission data vehicle(s) selected under § 76.078–24(b)(1)(v) shall represent all vehicles of the same engine system combination to be sold at high altitude.

(E) The emission data vehicle(s) selected under § 86.078–24(b)(1)(vii)(D) shall represent all vehicles of the same evaporative control system within the evaporative family sold at high altitude.

(b)(1)(ii) through (b)(1)(iii)(C) (See paragraphs (b)(1)(ii) through (b)(1)(iii)(C) of § 86.077–30)

(2) The Administrator will proceed as in paragraph (a) of this section with respect to the vehicles belonging to an engine family—evaporative family combination, all of which comply with all applicable standards.

(3) (See paragraph (b)(3) of § 86.077–30)

(4) The manufacturer may, at his option, proceed with any of the following alternatives with respect to an emission

data vehicle determined not in compliance with all applicable standards for which it was tested.

(I) Request a hearing under § 86.078–6; or

(ii) Remove the vehicle configuration (or evaporative vehicle configuration as applicable) which failed from his application;

(A) If the failed vehicle was tested for compliance with exhaust emission standards only: The Administrator may select, in place of the failed vehicle, in accordance with the selection criteria employed in selecting the failed vehicle, a new emission data vehicle to be tested for exhaust emission compliance only.

(B) If the failed vehicle was tested for compliance with both exhaust and evaporative emission standards: The Administrator may select, in place of the failed vehicle, in accordance with the selection criteria employed in selecting the failed vehicle, a new emission data vehicle which will be tested for compliance with both exhaust and evaporative emissions standards. If one vehicle cannot be selected in accordance with the selection criteria employed in selecting the failed vehicle, then two vehicles may be selected (i.e., one vehicle to satisfy the exhaust emission vehicle-selection criteria, and one vehicle to satisfy the evaporative emission vehicle-selection criteria) both of which will be tested for compliance with both exhaust and evaporative emission standards; or

(iii) Remove the vehicle configuration (or evaporative vehicle configuration, as applicable) which failed from his application and add a vehicle configuration(s) (or evaporative vehicle configuration(s) as applicable) not previously listed. The Administrator may require if applicable that the failed vehicle be modified to the new engine code (or evaporative emission code as applicable) and demonstrate by testing that it meets applicable standards for which it was originally tested. In addition, the Administrator may select, in place of the failed vehicle, a new emission data vehicle (or vehicles) which may be tested for compliance with both exhaust and evaporative emissions standards; or

(iv) Correct a component or system malfunction and show that with a correctly functioning system or component, the failed vehicle meets applicable standards for which it was originally tested. The Administrator may require, a new emission data vehicle, of identical vehicle configuration (or evaporative vehicle configuration as applicable) to the failed vehicle, to be operated and tested for compliance with the applicable standards for which the failed vehicle was originally tested.

(c) (See paragraph (C) of § 86.077–30)

14. A new § 86.078–35 is added and reads as follows:

§ 86.078–35 Labeling.

(a) Through (a)(1)(iii)(B) (See paragraphs (a) through (a)(1)(iii)(B) or § 86.077–35)

(C) Engine displacement (in cubic inches), engine family identification and evaporative family identification.

(a)(1)(iii)(D) through (c) (See paragraph (a)(1)(iii)(D) through paragraph (c) of § 86.077–35).

15. Subpart B is enlarged by adding §§ 86.101–78 through 86.145–78 (effective for the 1978 model year) which read as follows:

Subpart B—Emission Regulations for 1977 and Later Model Year New Light Duty Vehicles and New Light Duty Trucks; Test Procedures

Sec.

86.101 Applicability.
86.102 Definitions.
86.103 Abbreviations.
86.104 Section numbering, construction.
86.105 Introduction; structure of subpart.
86.106 Equipment required; overview.
86.107 Sampling, and analytical system evaporative emissions.
86.108 Dynamometer.
86.109 Exhaust gas sampling system.
86.110 [Reserved]
86.111 Exhaust gas analytical system.
86.112 [Reserved]
86.113 Fuel specifications.
86.114 Analytical gases.
86.115 EPA urban dynamometer driving schedule.
86.116 Calibrations, frequency and overview.
86.117 Evaporative emission enclosure calibrations.
86.118 Dynamometer calibration.
86.119 Constant volume sampler calibration.
86.120 [Reserved]
86.121 Hydrocarbon analyzer calibration.
86.122 Carbon monoxide analyzer calibration.
86.123 Oxides of nitrogen analyzer calibration.
86.124 Carbon dioxide analyzer calibration.
86.125 [Reserved]
86.126 Calibration of other equipment.
86.127 Test procedures, overview.
86.128 Transmissions.
86.129 Road load power and inertia weight determination.
86.130 Test sequence, general requirements.
86.131 Vehicle preparation.
86.132 Vehicle preconditioning.
86.133 Diurnal breathing loss test.
86.134 Running loss test.
86.135 Dynamometer procedure.
86.136 Engine starting and restarting.
86.137 Dynamometer test runs.
86.138 Hot soak test.
86.139 [Reserved]
86.140 Exhaust sample analysis.
86.141 [Reserved]
86.142 Records required.
86.143 Calculations; evaporative emissions.
86.144 Calculations; exhaust emissions.
86.145 [Reserved]

AUTHORITY: Secs. 202, 206, 207, 208, and 301(a) of the Clean Air Act, as amended (42 U.S.C. 1857F–1, 1857F–5, 1857F–5a, 1857F–6, 1857g(a))

Subpart B—Emission Regulations for 1977 and Later Model Year New Light Duty Vehicles and New Light Duty Trucks; Test Procedures

§ 86.101–78 General applicability.

(a) The provisions of this subpart are applicable to 1977 and later model year new light duty vehicles and light duty trucks.

(1) Sections 86.101–78 through 86.145–78 apply for 1978 and later model years.

(2) Sections 86.177–1 through 86.177–23 apply for the 1977 model year only.

(b) Provisions of this subpart apply to tests performed by both the Administrator and motor vehicle manufacturers.

§ 86.102–78 Definitions.

The definitions in §§ 86.077–2 and 86.078–2 apply to this subpart.

§ 86.103–78 Abbreviations.

The abbreviations in § 86.078–3 apply to this subpart.

§ 86.104–78 Section numbering, construction.

(a) The model year of initial applicability is indicated by the section number. The two digits following the hyphen designate the first model year for which a section is effective. A section remains effective until superseded.

Example. Section 86.111–78 applies to the 1978 and subsequent model years until superseded. If a § 86.111–81 is promulgated it would take effect beginning with the 1981 model year; § 86.111–78 would apply to model years 1978 through 1980.

(b) Unless indicated, all provisions in this subpart apply to both gasoline and diesel fueled vehicles.

§ 86.105–78 Introduction, structure of subpart.

(a) This subpart describes the equipment required and the procedures to follow in order to perform exhaust and evaporative emission tests on light duty vehicles and light duty trucks. This Subpart A sets forth the testing requirements and test intervals necessary to comply with EPA certification procedures.

(b) Three topics are addressed in this subpart. Sections 86.106 through 86.115 set forth specifications and equipment requirements; §§ 86.116 through 86.126 discuss calibration methods and frequency; test procedures and data requirements are listed (in approximate order of performance) in §§ 86.127 through 86.145.

§ 86.106–78 Equipment required; overview.

(a) This subpart contains procedures for both exhaust and evaporative emissions tests on diesel or gasoline fueled light duty vehicles and light duty trucks. Certain items of equipment are not necessary for a particular test, e.g., evaporative enclosure when testing diesel vehicles. Equipment required and specifications are as follows:

(1) *Evaporative emission tests, gasoline fueled vehicles.* The evaporative emission test is closely related to and connected with the exhaust emission test. All vehicles tested for evaporative emissions must be tested for exhaust emissions. Further, unless the evaporative emission test is waived by the Administrator under § 86.077–26, all gasoline fueled vehicles must undergo both tests. (Diesel vehicles are excluded from the evaporative emission standard.) Section 86.107 specifies the necessary equipment.

(2) *Exhaust emission tests.* All vehicles subject to this subpart are tested for exhaust emissions. Diesel and gasoline fueled vehicles are tested identically with

the exception of hydrocarbon measurements; diesel vehicles require a heated hydrocarbon detector, § 86.109. All gasoline fueled vehicles are either tested for evaporative emissions or undergo a diurnal heat build, diesel vehicles are excluded from this requirement. Equipment necessary and specifications appear in §§ 86.108 through 86.114.

(3) *Fuel, analytical gas, and driving schedule specifications.* Fuel specifications for exhaust and evaporative emission testing and for mileage accumulation for gasoline and diesel fueled vehicles are specified in § 86.113. Analytical gases are specified in § 86.114. The EPA Urban Dynamometer Driving Schedule for use in exhaust testing is specified in § 86.115 and Appendix I.

§ 86.107–78 Sampling and analytical system, evaporative emissions.

(a) Component description (evaporative emissions sampling system). The following components will be used in evaporative emissions sampling systems for testing under this subpart.

(1) *Evaporative emission measurement enclosure.* The enclosure shall be readily sealable, rectangular in shape, with space for personnel access to all sides of the vehicle. When sealed, the enclosure shall be gas tight in accordance with § 86.117. Interior surfaces must be impermeable to hydrocarbons. One surface should be of flexible, impermeable material to allow for minor volume changes, resulting from temperature changes. Wall design should promote maximum dissipation of heat, and if artificial cooling is used, interior surface temperatures shall not be less than 68° F (20° C).

(2) *Evaporative emission hydrocarbon analyzers.* A hydrocarbon analyzer utilizing the hydrogen flame ionization principle (FID) shall be used to monitor the atmosphere within the enclosure. Instrument bypass flow may be returned to the enclosure. The FID shall have a response time to 90 percent of final reading of less than 1.5 s, and be capable of meeting performance requirements expressed as a function of C_{std}; where C_{std} is the specific enclosure hydrocarbon level, in ppm, corresponding to the evaporative emission standard:

(i) Stability of the analyzer shall be better than 0.01 C_{std} ppm at both zero and $C_{std}\pm5$ ppm over a 15 minute period on all ranges used;

(ii) Repeatability of the analyzer, expressed as one standard deviation, shall be better than 0.005 C_{std} ppm at both zero and $C_{std}\pm5$ ppm on all ranges used.

(3) *Evaporative emission hydrocarbon data recording system.* The electrical output of the FID shall be recorded at least at the initiation and termination of each diurnal or hot soak. The recording may be by means of a strip chart potentiometric recorder, by use of an on-line computer system or other suitable means. In any case, the recording system must have operational chracteristics (signal to noise ratio, speed of response, etc.) equivalent to or better than those of the signal source being recorded, and must provide a permanent record of results. The record shall show a positive indication of the initiation and completion of each diurnal or hot soak along with the time elapsed between initiation and completion of each soak.

(4) *Tank fuel heating system.* The tank fuel heating system shall consist of a heat source and a temperature controller. A typical heat source is a 2000 w heating pad. Other sources may be used as required by circumstances. The temperature controller may be manual, such as a variable voltage transformer, or may be automated. The heating system must not cause hot spots on the tank wetted surface which could cause local overheating of the fuel. Heat must not be applied to the vapor in the tank above the liquid fuel. The temperature controller must be capable of controlling the fuel tank temperature during the diurnal soak to within ±3° F (1.7° C) of the following equation:

$$F=T_o+0.4\ t$$

or for SI units:

$$C=T_o+(2/9)t$$

Where:

F=Temperature in °F
C=Temperature in °C
t=Time since start of test in minutes
T_o=Initial temperature

(5) *Temperature recording system.* Strip chart recorder(s) or automatic data processor shall be used to record enclosure ambient and vehicle fuel tank temperature during the evaporative emissions test. The temperature recorder or data processor shall record each temperature at least once every minute. The recording system shall be capable of resolving time to ±15s and capable of resolving temperature to ±0.75° F (0.42° C). The temperature recording system (recorder and sensor) shall have an accuracy of ±2° F (1.1° C). The recorder (data processor) shall have a time accuracy of ±15s and a precision of ±15s. Two ambient temperature sensors, connected to provide one average output, shall be located in the enclosure. These sensors shall be located at the approximate vertical centerline of each side wall extending 4 inches (nominally) into the enclosure at a height of 3±0.5 ft (0.9±0.2 m). The vehicle fuel tank temperature sensor shall be located in the fuel tank so as to measure the temperature of the prescribed test fuel at the approximate mid-volume of the fuel. Manufacturers shall arrange that vehicles furnished for testing at Federal certification facilities be equipped with iron-constantan Type J thermocouples for measurement of fuel tank temperature.

(6) *Purge blower.* One or more portable or fixed blowers shall be used to purge the enclosure. The blowers shall have sufficient flow capacity to reduce the enclosure hydrocarbon concentration from the test level to the ambient level between tests. Actual flow capacity will depend upon the time available between tests.

(7) *Mixing blower.* One or more small blowers or fans with a total capacity of 200 to 1000 cfm shall be used to mix the contents of the enclosure during evaporative emission testing. No portion of the air stream shall be directed towards the vehicle. Maintenance of uniform concentrations throughout the enclosure is important to the accuracy of the test.

§ 86.108–78 Dynamometer.

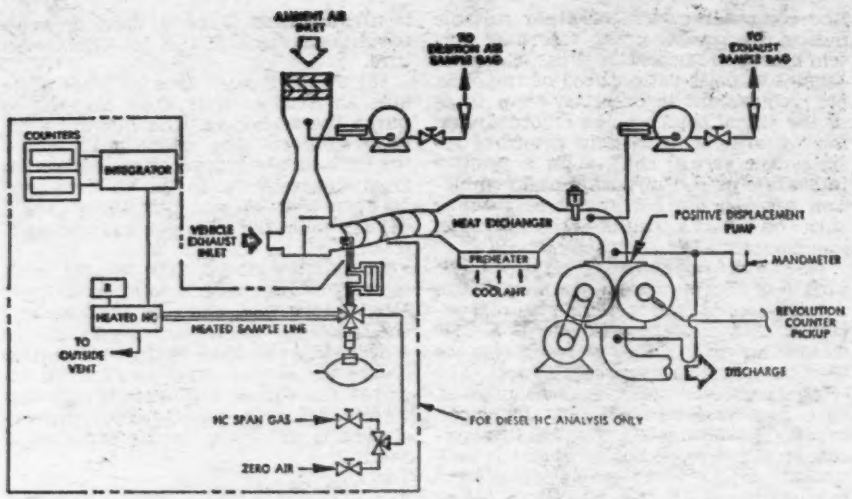
The dynamometer shall have a power absorption unit for simmulation of road load power and flywheels or other means of simulating the inertia weight as specified in § 86.129.

§ 86.109–78 Exhaust gas sampling system.

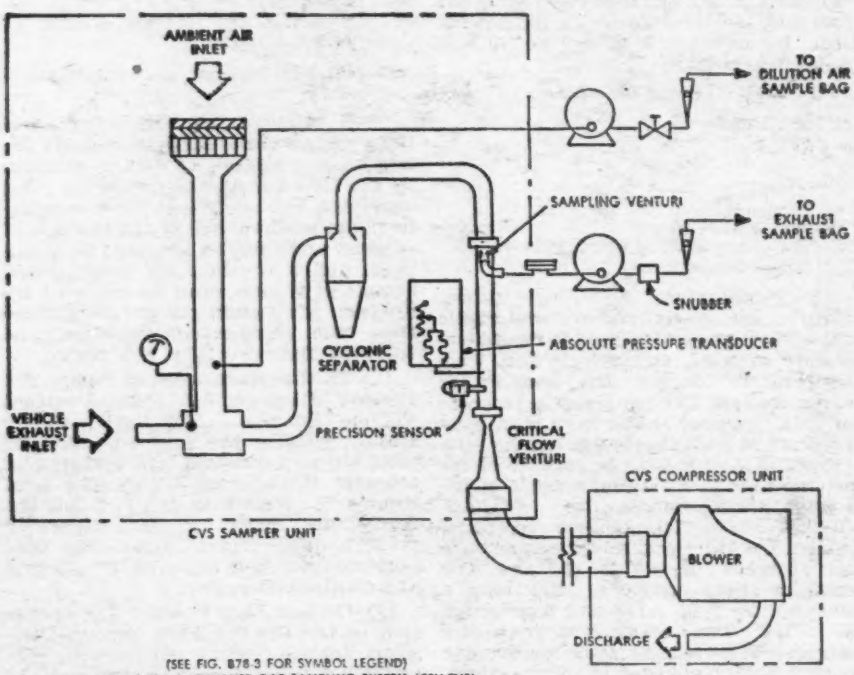
(a) (1) *General.* The exhaust gas sampling system is designed to measure the true mass emissions of vehicle exhaust. In the CVS concept of measuring mass emissions, two conditions must be satisfied; the total volume of the mixture of exhaust and dilution air must be measured, and a continuously proportioned sample of volume must be collected for analysis. Mass emissions are determined from the sample concentration and totalized flow over the test period.

(2) *Positive Displacement Pump.* The Positive Displacement Pump-Constant Volume Sampler (PDP–CVS), Figure B78–1, satisfies the first condition by metering at a constant temperature and pressure through the pump. The total volume is measured by counting the revolutions made by the calibrated positive displacement pump. The proportional sample is achieved by sampling at a constant flow rate.

(3) *Critical Flow Venturi.* The operation of the Critical Flow Venturi-Constant Volume Sample (CFV–CVS), Figure B78–2, is based upon the principles of fluid dynamics associated with critical flow. Proportional sampling throughout temperature excursions is maintained by use of a small CFV in the sample line. The variable mixture flow rate is maintained at sonic velocity, which is directly proportional to the square root of the gas temperature, and is computed continuously. Since the pressure and temperature are the same at both venturi inlets, the sample volume is proportional to the total volume.



(SEE FIG. B78-3 FOR SYMBOL LEGEND)
FIGURE B78-1—EXHAUST GAS SAMPLING SYSTEM (PDP-CVS)



(SEE FIG. B78-3 FOR SYMBOL LEGEND)
FIGURE B78-2—EXHAUST GAS SAMPLING SYSTEM (CFV-CVS)

(4) *Diesel sampling.* Diesel vehicles require a heated flame ionization detector (HFID) for hydrocarbon analysis. The sample must be taken as close as practical to the mixing point of the dilution air and exhaust sample. The HFID, by design, draws its sample at a constant flow rate. Unless compensation for varying flow is made the HFID must be used with a constant flow system to insure a representative sample.

(5) *Other systems.* Other sampling systems may be used if shown to yield equivalent results, and if approved in advance by the Administrator (e.g., a heat exchanger with the CFV–CVS; an electronic flow integrator without a heat exchanger, with the PDP–CVS; or, for diesel HC measurements, an electronic flow compensator with the CFV–CVS).

(b) *Component description, PDP–CVS.* The PDP–CVS, Figure B78–1, consists of a dilution air filter and mixing assembly, heat exchanger, positive displacement pump, sampling system, and associated valves, pressure and temperature sensors. The PDP–CVS shall conform to the following requirements:

(1) Static pressure variations at the tailpipe(s) of the vehicle shall remain within ±5 inches of water (1.2 kPa) of the static pressure variations measured during a dynamometer driving cycle with no connection to the tailpipe(s). (Sampling systems capable of maintaining the static pressure to within ±1 inch of water (0.25 kPa) will be used by the Administrator if a written request substantiates the need for this closer tolerance.)

(2) The gas mixture temperature, measured at a point immediately ahead of the positive displacement pump, shall be within ±10° F (5.6° C) of the designed operating temperature at the start of the test. The gas mixture temperature variation from its value at the start of the test shall be limited to ±10° F (5.6° C) during the entire test. The temperature measuring system shall have an accuracy and precision of ±2° F (1.1° C).

(3) The pressure gauges shall have an accuracy and precision of ±3 mm Hg (0.4 kPa).

(4) The flow capacity of the CVS shall be large enough to eliminate water condensation in the system (300 to 350 cfm, 0.140 to 0.165 m^3/s, is sufficient for most vehicles).

(5) Sample collection bags for dilution air and exhaust samples shall be of sufficient size so as not to impede sample flow.

(c) *Component description, CFV–CVS.* The CFV–CVS, Figure B78–2 consists of a dilution air filter and mixing assembly, cyclone particulate separator, sampling venturi, critical flow venturi, sampling system, and assorted valves, pressure and temperature sensors. The CFV–CVS shall conform to the following requirements:

(1) Static pressure variations at the tailpipe(s) of the vehicle shall remain within ±5 inches of water (1.2 kPa) of the static pressure variations measured during a dynamometer driving cycle with no connection to the tailpipe(s). (Sampling systems capable of maintaining the static pressure to within ±1 inch of water (0.25 kPa) will be used by the Administrator if a written request substantiates the need for this closer tolerance.)

(2) The temperature measuring system shall have an accuracy and precision of ±2° F (1.1° C) and a response time of 0.100 s to 62.5% of a temperature change (as measured in hot silicone oil).

(3) The pressure measuring system shall have an accuracy and precision of ±3 mm Hg (0.4 kPa).

(4) The flow capacity of the CVS shall be large enough to virtually eliminate water condensation in the system (300 to 350 cfm, 0.142 to 0.165 m^3/s, is sufficient for most vehicles).

(5) Sample collection bags for dilution air and exhaust samples shall be of sufficient size so as not to impede sample flow.

§ 86.110–78 [Reserved]

§ 86.111–78 Exhaust gas analytical system.

(a) *Schematic drawings.* Figure B78–3 is a schematic drawing of the exhaust gas analytical system. The schematic of the hydrocarbon analysis train for diesel fueled vehicles is shown as part of Figure B78–1. Since various configurations can produce accurate results, exact conformance with either drawing is not required. Additional components such as instruments, valves, solenoids, pumps and switches may be used to provide addi-

tional information and coordinate the functions of the component systems.

(b) *Major component description.* The analytical system, Figure B78–3, consists of a flame ionization detector (FID) for the determination of hydrocarbons, nondispersive infrared analyzers (NDIR) for the determination of carbon monoxide and carbon dioxide and a chemiluminescence analyzer (CL) for the determination of oxides of nitrogen. A heated flame ionization detector (HFID) is used for the continuous determination of hydrocarbons from diesel fueled vehicles, Figure B78–1. The exhaust gas analytical system shall conform to the following requirements:

(1) The chemiluminescence analyzer requires that the nitrogen dioxide present in the sample be converted to nitric oxide before analysis. Other types of analyzers may be used if shown to yield equivalent results and if approved in advance by the Administrator.

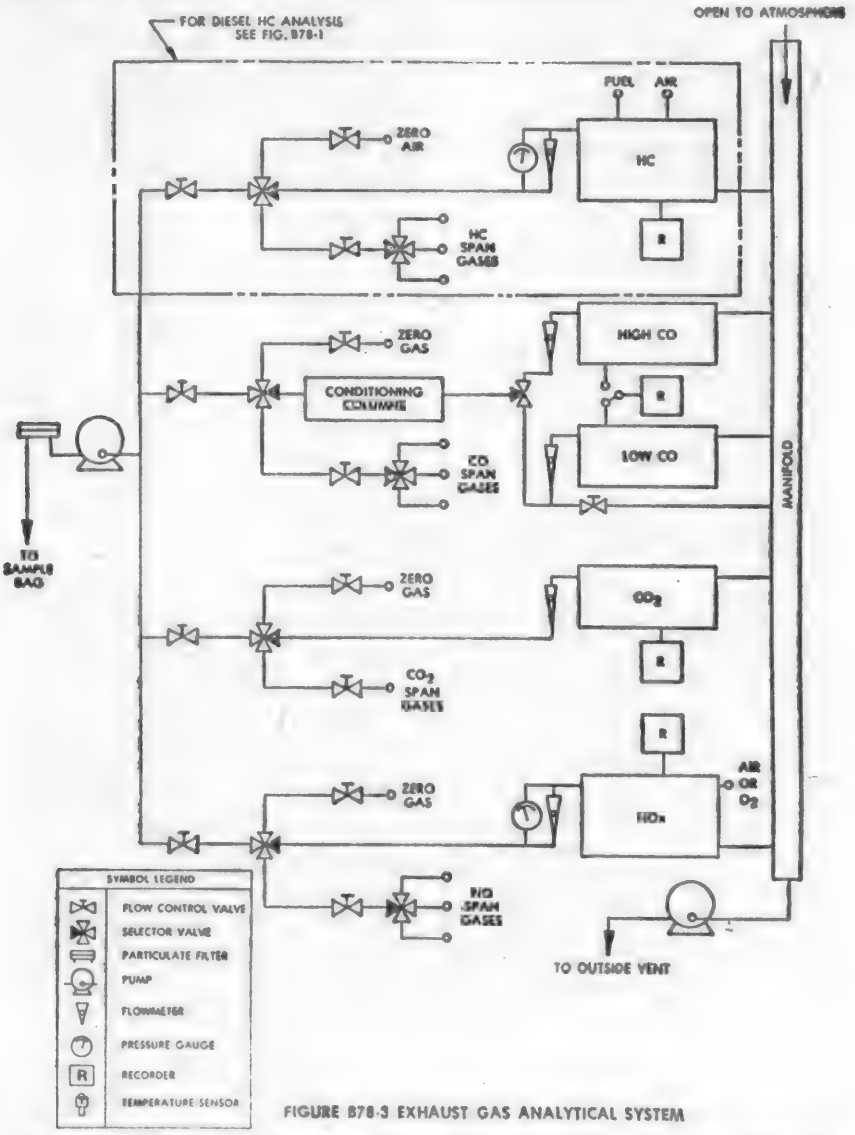


FIGURE B78-3 EXHAUST GAS ANALYTICAL SYSTEM

(2) The carbon monoxide (NDIR) analyzer may require a sample conditioning column containing $CaSO_4$, or indicating silica gel to remove water vapor and containing ascarite to remove carbon dioxide from the CO analysis stream.

(i) If CO instruments which are essentially free of CO_2 and water vapor interference are used, the use of the conditioning column may be deleted, see §§ 86.-122 and 86.144.

(ii) A CO instrument will be considered to be essentially free of CO_2 and water vapor interference if its response to a mixture of 3 percent CO_2 in N_2 which has been bubbled through water at room temperature produces an equivalent CO response, as measured on the most sensi-

tive CO range, which is less than 1 percent of full scale CO concentration on ranges above 300 ppm full scale or less than 3 ppm on ranges below 300 ppm full scale, see § 86.122.

(3) For diesel fueled vehicles a continuous sample shall be measured using a heated analyzer train as shown in Figure B78–1. The train shall include a heated continuous sampling line, a heated particulate filter and a heated hydrocarbon instrument (HFID) complete with heated pump, filter and flow control system.

(i) The response time of this instrument shall be less than 1.5 seconds for 90 percent of full-scale response.

(ii) Sample transport time from sampling point to inlet of instrument shall be less than 4 seconds.

(iii) The sample line and filter shall be heated to a set point ±10° F (±5.6° C) between 300 and 390° F (149 and 199° C).

(c) *Other analyzers and equipment.* Other types of analyzers and equipment may be used if shown to yield equivalent results and if approved in advance by the Administrator.

§ 86.112–78 [Reserved]

§ 86.113–78 Fuel specifications.

(a) *Gasoline.* (1) Gasoline having the following specifications will be used by the Administrator in exhaust and evaporative emission testing. Gasoline having the following specifications or substantially equivalent specifications approved by the Administrator, shall be used by the manufacturer in exhaust and evaporative testing, except that the lead and octane specifications do not apply.

Item	ASTM	Leaded	Unleaded
Octane, research, minimum	D2699	100	96
Pb. (organic), grams/U.S. gallon		[1] 1.4	0.00–0.05
Distillation range:			
IBP [2], °F	D86	75–95	75–95
10 pct point, °F	D86	120–135	120–135
50 pct point, °F	D86	200–230	200–230
90 pct point, °F	D86	300–325	300–325
EP, °F (maximum)	D86	415	415
Sulphur, weight percent, maximum	D1266	0.10	0.10
Phosphorous, grams/U.S. gallon, maximum		0.01	0.004
RVP [3] [4], per square inch	D323	8.7–9.2	8.7–9.2
Hydrocarbon composition:			
Olefins, percent, maximum	D1319	10	10
Aromatics, percent, maximum	D1319	35	35
Saturates	D1319	[5]	[5]

[1] Minimum.
[2] For testing at altitudes above 1,219 m (4,000 ft) the specified range is 75–105.
[3] For testing which is unrelated to evaporative emission control, the specified range is 8.0–9.2.
[4] For testing at altitudes above 1,219 m (4,000 ft) the specified range is 7.9–9.2.
[5] Remainder.

(2) Gasoline representative of commercial gasoline which will be generally available through retail outlets shall be used in service accumulation. For leaded gasoline the minimum lead content shall be 1.4 grams per U.S. gallon, except that where the Administrator determines that vehicles represented by a test vehicle will be operated using gasoline of different lead content than that prescribed in this paragraph, he may consent in writing to use of a gasoline with a different lead content. The octane rating of the gasoline used shall be no higher than 4.0 research octane numbers above the minimum recommended by the manufacturer. The Reid Vapor Pressure of the gasoline used shall be characteristic of the motor fuel used during the season in which the service accumulation takes place.

(3) The specification range of the gasoline to be used under paragraph (a)(2) of this section shall be reported in accordance with § 86.077–21(b)(3).

(b) *Diesel fuel.* (1) The diesel fuels employed for testing shall be clean and bright, with pour and cloud points adequate for operability. The diesel fuel may contain nonmetallic additives as follows: Centane improver, metal deactivator, antioxidant, dehazer, antirust, pour depressant, dye, and dispersant.

(2) Diesel fuel meeting the following specifications, or substantially equivalent specifications approved by the Administrator, shall be used in exhaust emissions testing. The grade of diesel fuel recommended by the engine manufacturer commercially designated as "Type 1–D" or "Type 2–D", shall be used.

Item	ASTM	Type 1–D	Type 2–D
Cetane	D613	42–54	42–58
Distillation range	D86		
IBP, °F		330–390	340–400
10 pct point, °F		370–430	400–460
50 pct point, °F		410–480	470–540
90 pct point, °F		460–520	550–610
EP, °F		500–560	580–660
Gravity, °API	D287	40–44	33–37
Total sulfur, percent	D129 or D2622	0.05–0.20	0.2–0.5
Hydrocarbon composition	D1319		
Aromatics, percent		5–15	[1] 27
Paraffins, Naphtenes, Olefins		[2]	[2]
Flashpoint, °F (minimum)	D93	130	130
Viscosity, centistokes	D445	1.6–2.0	2.0–3.2

[1] Minimum.
[2] Remainder.

(3) Diesel fuel meeting the following specifications, or substantially equivalent specifications approved by the Administrator, shall be used in service accumulation. The grade of diesel fuel recommended by the engine manufacturer, commercially designated as "Type 1–D" or "Type 2–D", shall be used.

Item	ASTM	Type 1–D	Type 2–D
Cetane	D613	49–54	42–55
Distillation range	D86		
IBP, °F		330–390	340–410
10 pct point, °F		370–430	400–470
50 pct point, °F		410–480	470–540
90 pct point, °F		460–520	520–610
EP, °F		500–560	580–690
Gravity, °API	D287	40–44	33–40
Total sulfur, percent	D129 or D2622	0.05–0.20	0.2–0.5
Flashpoint, °F (minimum)	D93	120	130
Viscosity, centistokes	D445	1.6–2.0	2.0–3.2

(4) Other petroleum distillation fuel specifications:

(i) Other petroleum distillate fuels may be used for testing and service accumulation provided they are commercially available, and

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service, and

(iii) Use of a fuel listed under paragraphs (b) (2) and (b) (3) of this section would have a detrimental effect on emissions or durability, and

(iv) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(5) The specification range of the fuels to be used under paragraphs (b) (2), (b) (3), and (b) (4) of this section shall be reported in accordance with § 86.077–21(b) (3).

§ 86.114–78 Analytical gases.

(a) Analyzer gases.

(1) Gases for the CO and CO_2 analyzers shall be single blends of CO and CO_2 respectively using nitrogen as the diluent.

(2) Gases for the hydrocarbon analyzer shall be single blends of propane using air as the diluent.

(3) Gases for NOx analyzer shall be single blends of NO named as NOx with a maximum NO_2 concentration of 5 percent of the nominal value using nitrogen as the diluent.

(4) Fuel for the evaporative emission enclosure FID shall be a blend of 60 percent helium and 40 percent hydrogen containing less than 1 ppm equivalent carbon response. 98 to 100 percent hydrogen fuel may be used with advance approval by the Administrator.

(5) The allowable zero gas (air or nitrogen) impurity concentrations shall not exceed 1 ppm equivalent carbon response, 0.04 percent (400 ppm) carbon dioxide and 0.1 ppm nitric oxide.

(6) "Zero grade air" includes artificial "air" consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

(b) Calibration gases should be known to within ±2 percent of the true values.

§ 86.114–79 Analytical gases.

(a) Analyzer gases.

(1) Gases for the CO and CO_2 analyzers shall be single blends of CO and CO_2 respectively using nitrogen as the diluent.

(2) Gases for the hydrocarbon analyzer shall be single blends of propane using air as the diluent.

(3) Gases for NOx analyzer shall be single blends of NO named as NOx, with a maximum NO_2 concentration of 5 percent of the nominal value, using nitrogen as the diluent.

(4) Fuel for the evaporative emission enclosure FID shall be a blend of 40±2% hydrogen with the balance being helium. The mixture shall contain less than 1 ppm equivalent carbon response. 98 to 100 percent hydrogen fuel may be used with advance approval by the Administrator.

(5) The allowable zero gas (air or nitrogen) impurity concentrations shall not exceed 1 ppm equivalent carbon response, 1 ppm carbon monoxide, 0.04 percent (400 ppm) carbon dioxide and 0.1 ppm nitric oxide.

(6) "Zero grade air" includes artificial "air" consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

(b) Calibration gases shall be traceable to within 1 percent of NBS gas standards, or other gas standards which have been approved by the Administrator.

(c) Span gases shall be accurate to within 2 percent of true concentration, where true concentration refers to NBS gas standards, or other gas standards which have been approved by the Administrator.

§ 86.115–78 EPA urban dynamometer driving schedule.

(a) The dynamometer driving schedule is listed in Appendix I. The driving schedule is defined by a smooth trace drawn through the specified speed vs. time relationships. It consists of a nonrepetitive series of idle, acceleration, cruise, and deceleration modes of various time sequences and rates.

(b) The speed tolerance at any given time on the dynamometer driving schedule prescribed in Appendix I or as printed on a driver's aid chart approved by the Administrator, when conducted to meet the requirements of § 86.137 is defined by upper and lower limits. The upper limit is 2 mph (3.2 km/h) higher than the highest point on the trace within 1 second of the given time. The lower limit is 2 mph (3.2 km/h) lower than the lowest point on the trace within 1 second of the given time. Speed variations greater than the tolerances (such as may occur during gear changes) are acceptable provided they occur for less than 2 seconds on any occasion. Speeds lower than those prescribed are acceptable provided the vehicle is operated at maximum available power during such occurrences. When conducted to meet the requirements of § 86.128 the speed tolerance shall be as specified above, except that the upper and lower limits shall be 4 mph (6.4 km/h).

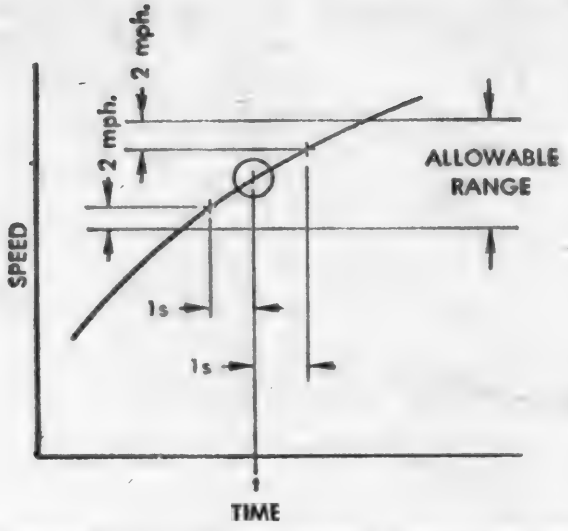


FIGURE B78-4a—DRIVERS TRACE, ALLOWABLE RANGE

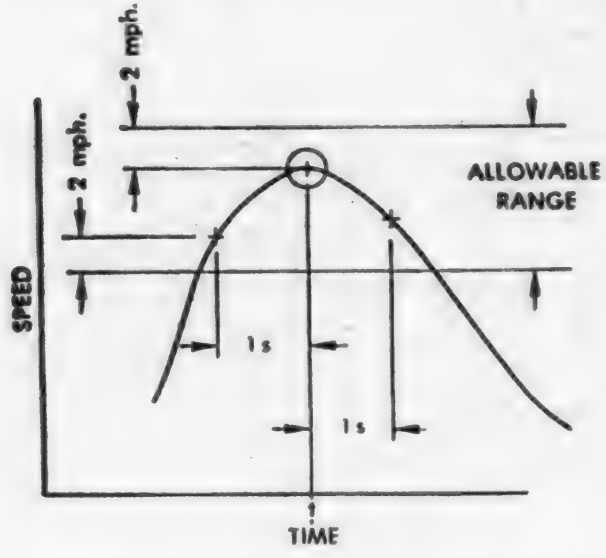


FIGURE B78-4b—DRIVERS TRACE, ALLOWABLE RANGE

(c) Figure B78–4 shows the range of acceptable speed tolerances for typical points. Figure B78–4(a) is typical of portions of the speed curve which are increasing or decreasing throughout the two second time interval. Figure B78–4 (b) is typical of portions of the speed curve which include a maximum or minimum value.

§ 86.116–78 Calibrations, frequency and overview.

(a) Calibrations shall be performed as specified in §§ 86.117 through 86.126.

(b) At least yearly or after any maintenance which could alter background emission levels, enclosure background emission measurements shall be performed.

(c) At least monthly or after any maintenance which could alter calibration, the following calibrations and checks shall be performed:

(1) Calibrate the hydrocarbon analyzers (both evaporative and exhaust instruments), carbon dioxide analyzer, carbon monoxide analyzer, oxides of nitrogen analyzer.

(2) Calibrate the dynamometer. If the dynamometer receives a weekly performance check (and remains within calibration) the monthly calibration need not be performed.

(3) Perform a hydrocarbon retention check and calibration on the evaporative emission enclosure.

(d) At least weekly or after any maintenance which could alter calibration, the following calibrations and checks shall be performed:

(1) Check the oxides of nitrogen converter efficiency, and

(2) Perform a CVS system verification, and

(3) Run a performance check on the dynamometer. This check may be omitted if the dynamometer has been calibrated within the preceding month.

(e) The CVS positive displacement pump or Critical Flow Venturi shall be calibrated following initial installation, major maintenance or as necessary when indicated by the CVS system verification (described in § 86.119).

(f) Sample conditioning columns, if used in the CO analyzer train, should be checked at a frequency consistent with observed column life or when the indicator of the column packing begins to show deterioration.

§ 86.117–78 Evaporative emission enclosure calibrations.

The calibration of the evaporative emission enclosure consists of three parts: Initial and periodic determination of enclosure background emissions; initial determination of enclosure internal volume; and periodic hydrocarbon retention check and calibration.

(a) *Initial and periodic determination of enclosure background emissions.* Prior to its introduction into service, annually thereafter, and after any repair which can affect the enclosure background emissions, the enclosure shall be checked to determine that it does not contain materials which will themselves emit hydrocarbons. Proceed as follows:

(1) Zero and span (calibrate if required) the hydrocarbon analyzer.

(2) Purge the enclosure until a stable background hydrocarbon reading is obtained.

(3) Turn on the mixing blower (if not already on).

(4) Seal enclosure and measure background hydrocarbon concentration, temperature, and barometric pressure. These are the initial readings C_{HCI}, T_I and P_{BI} for the enclosure background determination.

(5) Allow the enclosure to stand undisturbed without sampling for four hours.

(6) Measure the hydrocarbon concentration on the same FID. This is the final concentration, C_{HCF}. Also measure final temperature and barometric pressure.

(7) Calculate the mass change of hydrocarbons in the enclosure according to the equations in paragraph (d) of this section. The enclosure background emissions shall not be greater than 0.4g for the 4 hours.

(b) *Initial determination of enclosure internal volume.* Prior to its introduction into service the enclosure internal volume shall be determined by the following procedure.

(1) Carefully measure the internal length, width and height of the enclosure, accounting for irregularities (such as braces) and calculate the internal volume.

(2) Perform an enclosure calibration check according to paragraph (c)(1) through (7) of this section.

(3) If the calculated mass does not agree within 2 percent of the injected propane mass, then corrective action is required.

(c) *Hydrocarbon retention check and calibration.* The hydrocarbon retention check provides a check upon the calculated volume and also measures the leak rate. Prior to its introduction into service and at least monthly thereafter the enclosure leak rate shall be determined as follows:

(1) Zero and span (calibrate if required) the hydrocarbon analyzer.

(2) Purge the enclosure until a stable background hydrocarbon reading is obtained.

(3) Turn on the mixing blower (if not already on).

(4) Seal enclosure and measure background hydrocarbon concentration, temperature and barometric pressure. These are the initial readings C_{HCi}, T_i and P_{Bi} for the enclosure calibration.

(5) Inject into the enclosure a known quantity of pure propane. (4 g is a convenient quantity.) The propane may be measured by volume flow or by mass measurement. The method used to measure the propane shall have an accuracy and precision of ±0.5% of the measured value.

(6) After a minimum of five minutes of mixing, analyze the enclosure atmosphere for hydrocarbon content, also record temperature and pressure. These measurements are the final readings for the enclosure calibration as well as the initial readings for the retention check.

(7) To verify the enclosure calibration calculate the mass of propane using the measurements taken in steps (4) and (6). See paragraph (d) of this section. This quantity must be within ±2% of that measured in step 5 above.

(8) Allow the enclosure to remain sealed for a minimum of four hours without sampling and with the mixing blower operating. After four hours analyze the enclosure atmosphere for hydrocarbon content; record temperature and barometric pressure. These are the final readings for the hydrocarbon retention check.

(9) Calculate, using the equations in paragraph (d) and the readings taken in (8), the hydrocarbon mass. It may not differ by more than 4 percent of the value in step (6).

(d) *Calculations.* The calculation of net hydrocarbon mass change is used to determine enclosure background and leak rate. It is also used to check the enclosure volume measurements. The mass change is calculated from the initial and final readings of hydrocarbon concentration, temperature and pressure according to the following equation:

$$M_{HC} = kV \times 10^{-4} \left[\frac{C_{HCf} P_{Bf}}{T_f} - \frac{C_{HCi} P_{Bi}}{T_i} \right]$$

Where:

M_{HC} = Hydrocarbon mass change, g.
C_{HC} = Hydrocarbon concentration as ppm carbon.
V = Enclosure volume, ft^3 (m^3), as measured in paragraph (b)(1) of this section.
P_B = Barometric pressure, in. Hg (kPa).
T = Enclosure ambient temperature, R(K).
k = 3.05.

for SI units,

k = 17.60.
i = Indicates initial reading.
f = Indicates final reading.

NOTE: Hydrocarbon concentration is stated in ppm carbon, that is, ppm propane x3. Expressions in parenthesis are for SI units.

§ 86.118–78 Dynamometer calibration.

(a) The dynamometer shall be calibrated at least one each month or performance verified at least one each week and then calibrated as required. The calibration shall consist of the manufacturer's recommended calibration procedure plus a determination of the dynamometer frictional power absorption at 50.0 mph (80.5 km/h). One method for determining dynamometer frictional power absorption at 50.0 mph (80.5 km/h) is described below, other methods may be used if shown to yield equivalent results. The measured absorbed road power includes the dynamometer friction as well as the power absorbed by the power absorption unit. The dynamometer is driven above the test speed range. The device used to drive the dynamometer is then disengaged from the dynamometer and the roll(s) is (are) allowed to coast down. The kinetic energy of the system is dissipated by the dynamometer. This method neglects the variations in roll bearing friction due to the drive axle weight of the vehicle. The inertia of the free (rear) roll may be neglected in the case of dynamometers with paired rolls.

(1) Devise a method to determine the speed of the drive roll if it is not already measured. A fifth wheel, revolution pickup, or other suitable means may be used.

(2) Place a vehicle on the dynamometer or devise another method of driving the dynamometer.

(3) Engage the inertial flywheel or other inertial simulation system for the most common vehicle mass category for which the dynamometer is used. In addition other vehicle mass categories may be calibrated, if desired.

(4) Drive the dynamometer up to 50.0 mph (80.5 km/h).

(5) Record indicated road power.

(6) Drive the dynamometer up to 60.0 mph (96.9 km/h).

(7) Disengage the device used to drive the dynamometer.

(8) Record the time for the dynamometer drive roll to coastdown from 55.0 mph (88.5 km/h) to 45 mph (72.4 km/h).

(9) Adjust the power absorption unit to a different level.

(10) Repeat steps 4 to 9 above sufficient times to cover the range of road power used.

(11) Calculate absorbed road power (HP_d). See paragraph (c) of this section.

(12) Plot indicated road load power at 50 mph (80.5 km/h) versus road load power at 50 mph (80.5 km/h) as shown in Figure B78–5.

(b) The performance check consists of conducting a dynamometer coastdown at one or more inertia-horsepower settings and comparing the coastdown time to that recorded during the last calibration. If the coastdown times differ by more than 1 s, a new calibration is required.

(c) *Calculations.* The road load power actually absorbed by the dynamometer is calculated from the following equation:

$$HP_d = (1/2)\ (W/32.2)\ (V_1^2 - V_2^2)/550t$$

Where:

HP_d = Power, horsepower (kilowatts)
W = Equivalent inertia, lb (Kg)
V_1 = Initial Velocity, ft/s (m/s)
(55 mph = 88.5 km/h = 80.67 ft/s = 24.58 m/s)
V_2 = Final Velocity, ft/s (m/s)
(45 mph = 72.4 km/h = 66 ft/s = 20.11 m/s)

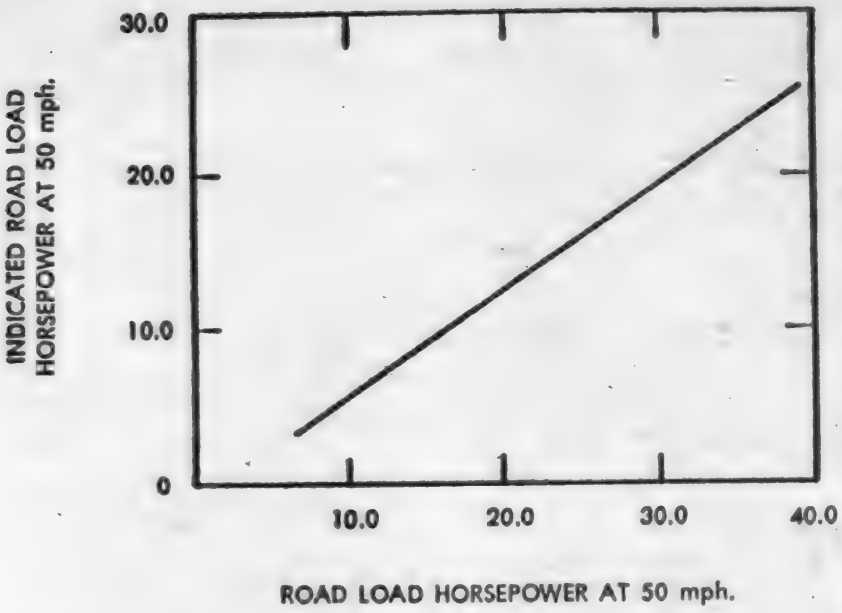


FIGURE B78-5—ROAD LOAD HORSEPOWER, ACTUAL VS. INDICATED

t=elapsed time for rolls to coast from 55 mph to 45 mph (88.5 to 72.4 km/h)

(Expressions in parenthesis are for SI units.) When the coastdown is from 55 to 45 mph (88.5 to 72.4 km/h) the above equation reduces to:

$HP_a = 0.06073\ (W/t)$
for SI units,
$HP_a = 0.09984\ (W/t)$

§ 86.119–78 CVS calibration.

The CVS (Constant Volume Sampler) is calibrated using an accurate flowmeter and restrictor valve. Measurements of various parameters are made and related to flow through the unit. Procedures used by EPA for both PDP (Positive Displacement Pump) and CFV (Critical Flow Venturi) are outlined below. Other procedures yielding equivalent results may be used if approved in advance by the Administrator. After the calibration curve has been obtained, verification of the entire system can be performed by injecting a known mass of gas into the system and comparing the mass indicated by the system to the true mass injected. An indicated error does not necessarily mean that the calibration is wrong, since other factors can influence the accuracy of the system, e.g. analyzer calibration. A verification procedure is found in paragraph (c) of this section.

(a) *PDP calibration.* (1) The following calibration procedure outlines the equipment, the test configuration, and the various parameters which must be measured to establish the flow rate of the constant volume sampler pump. All the parameters related to the pump are simultaneously measured with the parameters related to a flowmeter which is connected in series with the pump. The calculated flow rate ft³/min. (at pump inlet absolute pressure and temperature) can then be plotted versus a correlation function which is the value on a specific combination of pump parameters. The linear equation which relates the pump flow and the correlation function is then determined. In the event that a CVS has a multiple speed drive, a calibration for each range used must be performed.

(2) This calibration procedure is based on the measurement of the absolute values of the pump and flowmeter parameters that relate the flow rate at each point. Three conditions must be maintained to assure the accuracy and integrity of the calibration curve. First, the pump pressures should be measured at taps on the pump rather than at the external piping on the pump inlet and outlet. Pressure taps that are mounted at the top center and bottom center of the pump drive headplate are exposed to the actual pump cavity pressures, and therefore reflect the absolute pressure differentials. Secondly, temperature stability must be maintained during the calibration. The laminar flowmeter is sensitive to inlet temperature oscillations which cause the data points to be scattered. Gradual changes (±2° F (1.1° C)) in temperature are acceptable as long as they occur over a period of several minutes. Finally, all connections between the flowmeter and the CVS pump must be absolutely void of any leakage.

(3) During an exhaust emission test the measurement of these same pump parameters enables the user to calculate the flow rate from the calibration equation.

(4) Connect a system as shown in Figure B78–6. Although particular types of equipment are shown, other configurations that yield equivalent results may be used if approved in advance by the Administrator. For the system indicated, the following data with given accuracy are required:

CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Tolerances
Barometric pressure (corrected)	P_B	Inches Hg (kPa).	±.01 in Hg (±.034 kPa).
Ambient temperature	T_A	°F (°C).	±.5°F (±.28°C).
Air temperature into LFE	ETI	°F (°C).	±.25°F (±.14°C).
Pressure depression upstream of LFE	EPI	Inches H_2O (kPa).	±.05 in H_2O (±.012 kPa).
Pressure drop across the LFE matrix	EDP	Inches H_2O (kPa).	±.005 in H_2O (±.001 kPa).
Air temperature at CVS pump inlet	PTI	°F (°C).	±.5°F (±.28°C).
Pressure depression at CVS pump inlet	PPI	Inches fluid (kPa).	±.05 in fluid (±.022 kPa).
Specific gravity of manometer fluid (1.75 oil).	Sp. Gr		
Pressure head at CVS pump outlet	PPO	Inches fluid (kPa).	±.05 in fluid (±.022 kPa).
Air temperature at CVS pump outlet (optional).	PTO	°F (°C).	±.5°F (±.28°C).
Pump revolutions during test period	N	Revs.	±1 Rev.
Elapsed time for test period	t	s.	±.05 s.

(5) After the system has been connected as shown in Figure B78–6, set the variable restrictor in the wide open position and run the CVS pump for twenty minutes. Record the calibration data.

(6) Reset the restrictor valve to a more restricted condition in an increment of pump inlet depression (about 4" H_2O (1.0 kPa) that will yield a minimum of six data points for the total calibration. Allow the system to stabilize for 3 minutes and repeat the data acquisition.

(7) Data analysis:

(i) The air flow rate, Qs, at each test point is calculated in standard cubic feet per minute from the flowmeter data using the manufacturer's prescribed method.

(ii) The air flow rate is then converted to pump flow, V_o, in cubic feet per revolution at absolute pump inlet temperature and pressure.

$$V_o = \frac{Qs}{n} \times \frac{T_p}{528} \times \frac{29.92}{P_p}$$

Where:

V_o = Pump flow, ft^3/revolution (m^3/revolution) at T_p, P_p

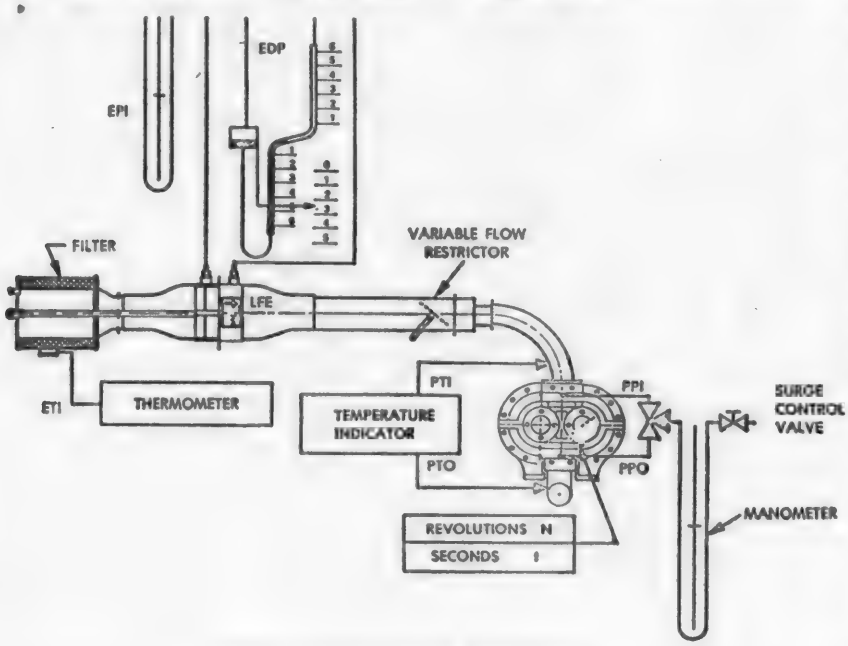


FIGURE B78-6—PDP-CVS CALIBRATION CONFIGURATION

Qs = Meter air flow rate in standard cubic feet per minute, standard conditions are 68° F, 29.92 in. Hg (20° C, 101.3 kPa).

n = Pump speed in revolutions per minute.

T_p = Pump inlet temperature, R(K) = PTI + 460

for SI units, T_p = PTI + 273

P_p = Absolute pump inlet pressure, in. Hg (kPa) = P_B − PPI (SP. GR./13.57)

for SI units, $P_p = P_B - PPI$

Where:

P_B = barometric pressure, in. Hg (kPa)

PPI = Pump inlet depression, in. fluid (kPa)

SP. GR. = Specific gravity of manometer fluid relative to water.

(iii) The correlation function at each test point is then calculated from the calibration data:

$$X_o = \frac{1}{n}\sqrt{\frac{\Delta P_p}{P_e}}$$

Where:

X_o = correlation function.

ΔP_p = The pressure differential from pump inlet to pump outlet, in. Hg (kPa) = $P_e - P_p$

P_e = Absolute pump outlet pressure, in. Hg (kPa) = P_B + PPO (SP. GR./13.57)

for SI units, $P_e = P_B + PPO$

Where:

PPO = Pressure head at pump outlet, in. fluid (kPa)

(iv) A linear least squares fit is performed to generate the calibration equations which have the forms:

$V_o = D_o - M(X_o)$

$n = A - B(\Delta P_p)$

D_o, M, A, and B are the slope-intercept constants describing the lines.

(8) A CVS system that has multiple speeds should be calibrated on each speed used. The calibration curves generated for the ranges will be approximately parallel and the intercept values, D_o, will increase as the pump flow range decreases.

(9) If the calibration has been performed carefully, the calculated values from the equation will be within ±0.50% of the measured value of V_o. Values of M will vary from one pump to another, but values of D_o for pumps of the same make, model, and range should agree within ±3% of each other. Particulate influx from use will cause the pump slip to decrease as reflected by lower values for M. Calibrations should be performed at pump start-up and after major maintenance to assure the stability of the pump slip rate. Analysis of mass injection data will also reflect pump slip stability.

(b) *CFV calibration.* (1) Calibration of the Critical Flow Venturi (CFV) is based upon the flow equation for a crit-

ical venturi. Gas flow is a function of inlet pressure and temperature:

$$Q_s = \frac{K_v P}{\sqrt{T}}$$

Where:

Q_s = Flow
K_v = Calibration coefficient
P = Absolute pressure
T = Absolute temperature

The calibration procedure described below establishes the value of the calibration coefficient at measured values of pressure, temperature and air flow.

(2) The manufacturer's recommended procedure shall be followed by calibrating electronic portions of the CFV.

(3) Measurements necessary for flow calibration are as follows:

CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Tolerances
Barometric pressure (corrected)	Pa	Inches Hg (kPa)	±.01 in Hg (±.034 kPa).
Air temperature, flowmeter	ETI	°F (°C).	±.25°F (±.14°C).
Pressure depression upstream of LFE	EPI	Inches H_2O (kPa).	±.05 in H_2O (±.012 kPa).
Pressure drop across LFE matrix	EDF	Inches H_2O (kPa).	±.005 in H_2O (±.001 kPa).
Air flow	Q_s	Ft^3/min. (m^3/min.)	±.5 pct.
CFV inlet depression	PPI	Inches fluid (kPa).	±.05 in fluid (±.022 kPa).
Temperature at venturi inlet	T_v	°F (°C).	±.5°F (±.25°C).
Specific gravity of manometer fluid (1.75 oil).	Sp. Gr.		

(4) Set up equipment as shown in Figure B78–7 and check for leaks. Any leaks between the flow measuring device and the critical flow venturi will seriously affect the accuracy of the calibration.

(5) Set the variable flow restrictor to the open position, start the blower and allow the system to stabilize. Record data from all instruments.

(6) Vary the flow restrictor and make at least 8 readings across the critical flow range of the venturi.

(7) Data analysis: The data recorded during the calibration are to be used in the following calculations:

(i) The air flow rate, Qs, at each test point is calculated in standard cubic feet per minute from the flow meter data using the manufacturer's prescribed method.

(ii) Calculate values of the calibration coefficient for each test point:

$$K_v = \frac{Q_s \sqrt{T_v}}{P_v}$$

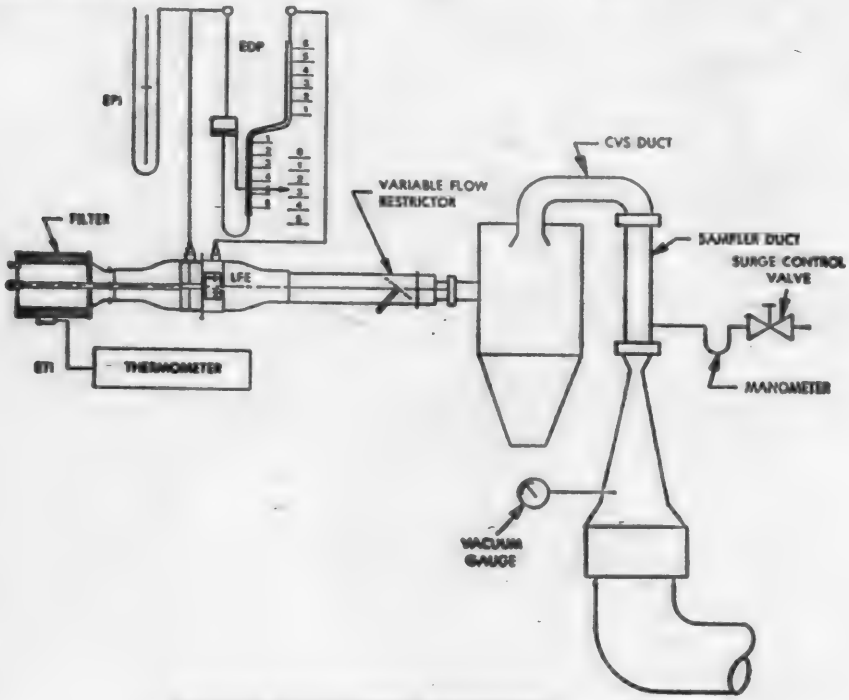


FIGURE B78-7 CFV-CVS CALIBRATION CONFIGURATION

Where:

Q_s=Flow rate in standard cubic feet per minute, standard conditions are 68° F, 29.92 in. Hg (20° C, 101.3 kPa).
T_v=Temperature at venturi inlet, R(K).
P_v=Pressure at venturi inlet, mm Hg (kPa) =P_B−PPI (SP. GR./13.57).

for SI units $P_v = P_B - PPI$.

Where:

PPI=Venturi inlet pressure depression, in. fluid (kPa).

SP. GR.=Specific gravity of manometer fluid, relative to water.

(iii) Plot K_v as a function of venturi inlet pressure. For sonic flow K_v will have a relatively constant value. As pressure decreases (vacuum increases) the venturi becomes unchocked and K_v decreases. See Figure B78–8.

(iv) For a minimum of 8 points in the critical region calculate an average K_v and the standard deviation.

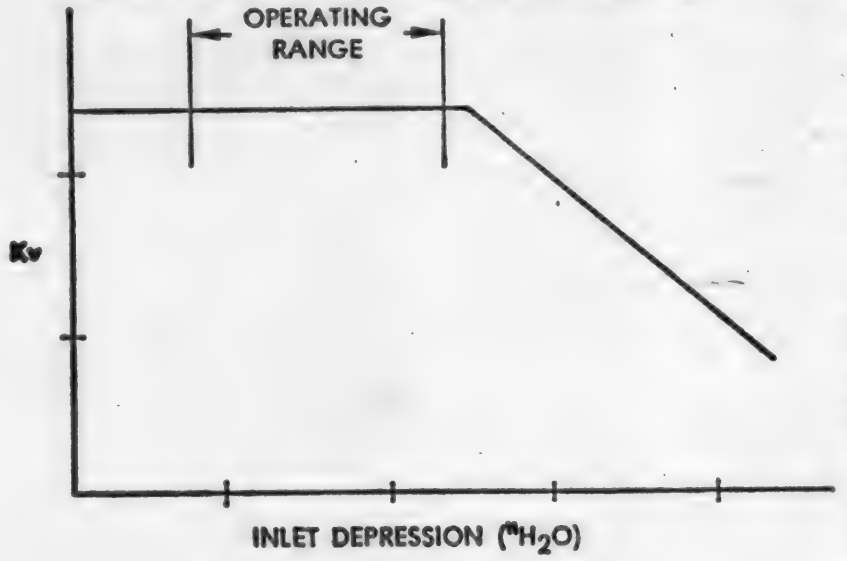


FIGURE B78-8—SONIC FLOW CHOKING

(v) If the standard deviation exceeds 0.3 percent of the average Kv take corrective action.

(c) *CVS System Verification.* The following "gravimetric" technique can be used to verify that the CVS and analytical instruments can accurately measure a mass of gas that has been injected into the system. (Verification can also be accomplished by constant flow metering using critical flow orifice devices.)

(1) Obtain a small cylinder that has been charged with pure propane or carbon monoxide gas (caution—carbon monoxide is poisonous).

(2) Determine a reference cylinder weight to the nearest 0.01 grams.

(3) Operate the CVS in the normal manner and release a quantity of pure propane or carbon monoxide into the system during the sampling period (approximately 5 minutes).

(4) The calculations of § 86.144 are performed in the normal way except, in the case of propane. The density of propane (17.30 g/ft³/carbon atom (0.6109 kg/m³/carbon atom)) is used in place of the density of exhaust hydrocarbons. In the case of carbon monoxide, the density of 32.97 g/ft³ (1.164 kg/m³) is used.

(5) The gravimetric mass is subtracted from the CVS measured mass and then divided by the gravimetric mass to determine the percent accuracy of the system.

(6) The cause for any discrepancy greater than ±2% percent must be found and corrected.

§ 86.120–78 [Reserved]

§ 86.121–78 Hydrocarbon analyzer calibration.

The FID hydrocarbon analyzer shall receive the following initial and periodic calibration. The HFID shall be operated to a set point ±10° F (±5.5° C) between 300 and 390° F (149 and 199° C).

(a) Initial and periodic optimization of detector response. Prior to its introduction into service and at least annually thereafter the FID hydrocarbon analyzer shall be adjusted for optimum hydrocarbon response. Alternate methods yielding equivalent results may be used, if approved in advance by the Administrator.

(1) Follow the manufacturer's instructions for instrument startup and basic operating adjustment using the appropriate fuel and zero grade air.

(2) Optimize on the most common operating range. Introduce into the analyzer, a propane in air mixture with a propane concentration equal to approximately 90 percent of the most common operating range.

(3) Select an operating fuel flow rate that will give near maximum response and least variation in response with minor fuel flow variations.

(4) To determine the optimum air flow, use the fuel flow setting determined above and vary air flow.

(5) After the optimum flow rates have been determined, they are recorded for future reference.

(b) Initial and periodic calibration. Prior to its introduction into service and monthly thereafter the FID hydrocarbon analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate as when analyzing samples.

(1) Adjust analyzer to optimize performance.

(2) Zero the hydrocarbon analyzer with zero grade air.

(3) Calibrate on each normally used operating range with propane in air calibration gases having nominal concentrations of 50 and 100 percent of that range. Additional calibration points may be generated.

§ 86.122–78 Carbon monoxide analyzer calibration.

The NDIR carbon monoxide analyzer shall receive the following initial and periodic calibrations:

(a) *Initial and periodic interference check.* Prior to its introduction into service and annually thereafter the NDIR carbon monoxide analyzer shall be checked for response to water vapor and CO_2:

(1) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance on the most sensitive range to be used.

(2) Zero the carbon monoxide analyzer with either zero grade air or zero grade nitrogen.

(3) Bubble a mixture of 3 percent CO_2 in N_2 through water at room temperature and record analyzer response.

(4) An analyzer response of more than 1 percent of full scale for ranges above 300 ppm full scale or of more than 3 ppm on ranges below 300 ppm full scale will require corrective action. (Use of conditioning columns is one form of corrective action which may be taken.)

(b) *Initial and periodic calibration.* Prior to its introduction into service and monthly thereafter the NDIR carbon monoxide analyzer shall be calibrated.

(1) Adjust the analyzer to optimize performance.

(2) Zero the carbon monoxide analyzer with either zero grade air or zero grade nitrogen.

(3) Calibrate on each normally used operating range with carbon monoxide in N_2 calibration gases having nominal concentrations of 15, 30, 45, 60, 75 and 90 percent of that range. Additional calibration points may be generated. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

§ 86.123–78 Oxides of nitrogen analyzer calibration.

The chemiluminescent oxides of nitrogen analyzer shall receive the following initial and periodic calibration.

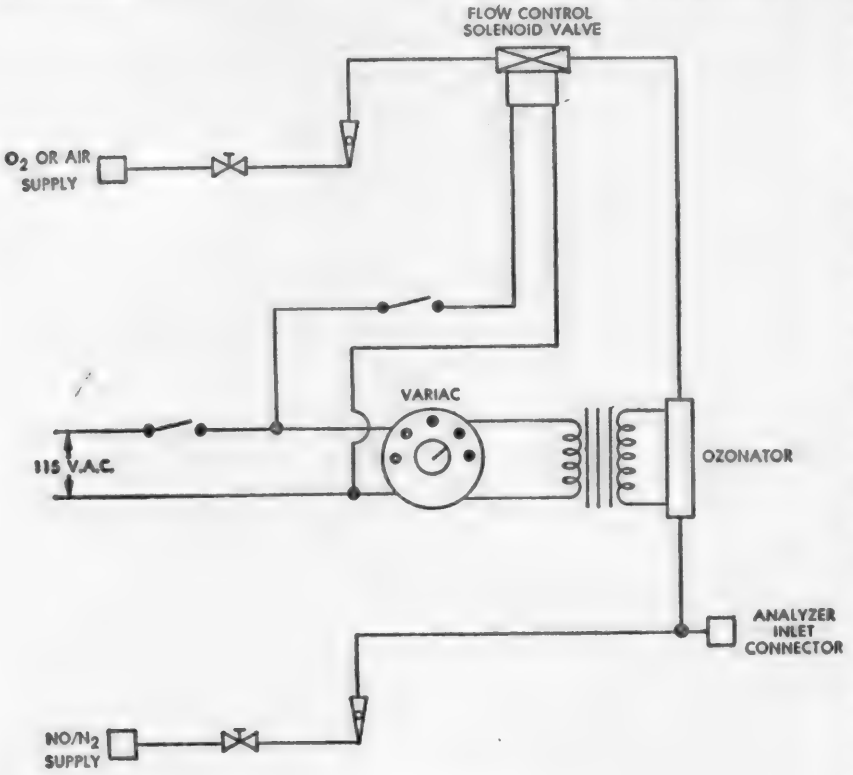
(a) Prior to its introduction into service and weekly thereafter the chemiluminescent oxides of nitrogen analyzer shall be checked for NO_2 to NO converter efficiency. Figure B78–9 is a reference for the following steps:

(1) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with zero grade air or zero grade nitrogen.

(3) Connect the outlet of the NOx generator to the sample inlet of the oxides of nitrogen analyzer which has been set to the most common operating range.

(4) Introduce into the NOx generator analyzer-system an NO in nitrogen (N_2) mixture with a NO concentration equal to approximately 80 percent of the most common operating range. The NO_2 content of the gas mixture shall be less than 5 percent of the NO concentration.



(SEE FIG B78-3 FOR SYMBOL LEGEND)
FIGURE B78-9—NOx CONVERTER EFFICIENCY DETECTOR

(5) With the oxides of nitrogen analyzer in the NO mode, record the concentration of NO indicated by the analyzer.

(6) Turn on the NOx generator O_2 (or air) supply and adjust the O_2 (or air) flow rate so that the NO indicated by the analyzer is about 10 percent less than indicated in step 5. Record the concentration of NO in this NO+O_2 mixture.

(7) Switch the NOx generator to the generation mode and adjust the generation rate so that the NO measured on the analyzer is 20 percent of that measured in step 5. There must be at least 10 percent unreacted NO at this point. Record the concentration of residual NO.

(8) Switch the oxides of nitrogen analyzer to the NOx mode and measure total NOx. Record this value.

(9) Switch off the NOx generation but maintain gas flow through the system. The oxides of nitrogen analyzer will indicate the NOx in the NO+O_2 mixture. Record this value.

(10) Turn off the NOx generator O_2 (or air) supply. The analyzer will now indicate the NOx in the original NO in N_2 mixture. This value should be no more than 5 percent above the value indicated in step 4.

(11) Calculate the efficiency of the NOx converted by substituting the concentrations obtained into the following equation:

$$\text{Percent Eff.} = \left(1 + \frac{a-b}{c-d}\right) \times 100$$

where a=concentration obtained in step 8.
b=concentration obtained in step 9.
c=concentration obtained in step 6.
d=concentration obtained in step 7.

If converter efficiency is not greater than 90 percent corrective action will be required.

(b) Initial and periodic calibration. Prior to its introduction into service and monthly thereafter the chemiluminescent oxides of nitrogen analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate as when analyzing samples. Proceed as follows:

(1) Adjust analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with zero grade air or zero grade nitrogen.

(3) Calibrate on each normally used operating range with NO in N_2 calibration gases with nominal concentrations of 50 and 100 percent of that range. Additional calibration points may be generated.

§ 86.124–78 Carbon dioxide analyzer calibration.

Prior to its introduction into service and monthly thereafter the NDIR carbon dioxide analyzer shall be calibrated:

(a) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance.

(b) Zero the carbon dioxide analyzer with either zero grade air or zero grade nitrogen.

(c) Calibrate on each normally used operating range with carbon dioxide in N_2 calibration gases with nominal concentrations of 15, 30, 45, 60, 75 and 90 percent of that range. Additional calibration points may be generated. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

§ 86.125–78 [Reserved]

§ 86.126–78 Calibration of other equipment.

Other test equipment used for testing shall be calibrated as often as required by the manufacturer or as necessary according to good practice.

§ 86.127–78 Test procedures, overview.

The procedures described in this and subsequent sections are used to determine

the conformity of vehicles with the standards set forth in Subpart A for light duty vehicles and light duty trucks.

(a) The overall test consists of prescribed sequences of fueling, parking and operating conditions. Vehicles are either tested for only exhaust emissions or are tested for exhaust and evaporative emissions. The evaporative portion of the test procedure occurs before and after the exhaust emission test, and, in some cases, during the exhaust emission test.

(b) The exhaust emission test is designed to determine hydrocarbon, carbon monoxide, and oxides of nitrogen mass emissions while simulating an average trip in an urban area of 7.5 miles (12.1 km). The test consists of engine startups and vehicle operation on a chassis dynamometer, through a specified driving schedule. A proportional part of the diluted exhaust emissions is collected continuously for subsequent analysis, using a constant volume (variable dilution) sampler (Diesel dilute exhaust is continuously analyzed for hydrocarbons using a heated sample line and analyzer).

(c) The evaporative emission test (gasoline fueled vehicles only) is designed to determine hydrocarbon evaporative emissions as a consequence of diurnal temperature fluctuation, urban driving, and hot soaks during parking. It is associated with a series of events representative of a motor vehicle's operation, which result in hydrocarbon vapor losses. The test procedure is designed to measure:

(1) Diurnal breathing losses resulting from daily temperature changes, measured by the enclosure technique;

(2) Running losses from suspected sources (if indicated by engineering analysis or vehicle inspection) resulting from a simulated trip on a chassis dynamometer, measured by carbon traps; and

(3) Hot soak losses which result when the vehicle is parked and the hot engine is turned off, measured by the enclosure technique.

(d) Except in cases of component malfunction or failure, all emission control systems installed on or incorporated in a new motor vehicle shall be functioning during all procedures in this subpart. Maintenance to correct component malfunction or failure shall be authorized in accordance with § 86.077.

§ 86.128–78 Transmissions.

(a) All test conditions shall be run with automatic and automatic stick shift transmissions in "Drive" (highest gear); manual transmissions shall be run in highest gear, except as noted. Automatic stick-shift transmissions may be shifted as manual transmissions if requested by the manufacturer.

(b) Cars equipped with free-wheeling or overdrive units shall be tested with these units locked out of operation.

(c) Idle modes shall be run with automatic transmissions in "Drive" and the wheels braked, manual transmissions shall be in gear with the clutch disengaged; except first idle, see §§ 86.136 and 86.137.

(d) The vehicle shall be driven with minimum accelerator pedal movement to maintain the desired speed.

(e) Acceleration modes shall be driven smoothly. Automatic transmissions shall shift automatically through the normal sequence of gears; manual transmissions shall be shifted as recommended by the manufacturer with the operator releasing the accelerator pedal during each shift and accomplishing the shift with minimum time. If the vehicle cannot accelerate at the specified rate, the vehicle shall be operated with the accelerator pedal fully depressed until the vehicle speed reaches the value prescribed for that time in the driving schedule.

(f) The deceleration modes shall be run in gear using brakes or accelerator pedal as necessary to maintain the desired speed. Manual transmission vehicles shall have the clutch engaged and shall not change gears from the previous mode. For those modes which decelerate to zero, manual transmission clutches shall be depressed when the speed drops below 15 mph (24.14 km/h), when engine roughness is evident, or when engine stalling is imminent.

(g) Manual transmissions will be down shifted at the beginning of or during a power mode if recommended by the manufacturer or if the engine obviously is lugging.

(h) If shift speeds are not recommended by the manufacturer, manual transmission vehicles shall be shifted from first to second gear at 15 mph (24.14 km/h), from second to third gear at 25 mph (40.23 km/h), and, if so equipped, from third to fourth gear at 40 mph (64.37 km/h). Fifth gear, if so equipped, may be used at the manufacturer's option.

(i) If a four- or five-speed manual transmission has a first gear ratio in excess of 5:1, follow the procedure for three- or four-speed vehicles as if the first gear did not exist.

§ 86.129–78 Road load power and inertia weight determination.

(a) Flywheels, electrical or other means of simulating inertia as shown in the following table shall be used. If the equivalent inertia specified is not available on the dynamometer being used, the next higher equivalent inertia (not to exceed 250 lbs) available shall be used.

Loaded vehicle weight (pounds)	Equivalent inertia weight (pounds)	Road load power at 50 mph (horsepower)
Up to 1,125	1,000	5.6
1,126 to 1,375	1,250	6.5
1,376 to 1,625	1,500	7.1
1,626 to 1,875	1,750	7.7
1,876 to 2,125	2,000	8.3
2,126 to 2,375	2,250	8.8
2,376 to 2,625	2,500	9.4
2,626 to 2,875	2,750	9.9
2,876 to 3,250	3,000	10.5
3,251 to 3,750	3,500	11.2
3,751 to 4,250	4,000	12.0
4,251 to 4,750	4,500	12.7
4,751 to 5,250	5,000	13.4
5,251 to 5,750	5,500	13.9
5,751 to above	5,500	14.4

(b) *Power absorption unit adjustment.* (1) The power absorption unit shall be adjusted to reproduce road load power at 50 mph true speed. The indicated road load power setting shall take into account the dynamometer friction. The relationship between road load (absorbed) power and indicated road load power for a particular dynamometer shall be determined by the procedure outlined in § 86.118 or other suitable means.

(2) The road load power listed in the table above shall be used or the vehicle manufacturer may determine the road load power by an alternate procedure requested by the manufacturer and approved in advance by the Administrator, or the vehicle manufacturer may determine the road load power by the following procedure and request its use:

(i) *Gasoline fueled vehicles.* (A) Measuring the absolute manifold pressure of a representative vehicle, of the same equivalent inertia weight class, when operated on a level road under balanced wind conditions at a true speed of 50 mph (80 km/h), and

(B) Noting the dynamometer indicated road load horsepower setting required to reproduce that manifold pressure when the same vehicle is operated on the dynamometer at a true speed of 50 mph. The tests on the road and on the dynamometer shall be performed with the same vehicle ambient absolute pressure (usually barometric), i.e., within ±5 mm Hg (±0.7 kPa).

(C) The road load power shall be determined according to the procedure outlined in § 86.118 and adjusted according to the following if applicable.

(ii) *Diesel vehicles.* (A) Measuring the fuel flow rate of a representative vehicle of the same equivalent inertia weight class, when operated on a level road under balanced wind conditions at a true speed of 50 mph, and

(B) Noting the dynamometer indicated road load horsepower setting required to reproduce that fuel flow rate when the same vehicle is operated on the dynamometer at a true speed of 50 mph (80 km/h). The tests on the road and on the dynamometer shall be performed with the same vehicle ambient absolute pressure (usually barometric), i.e. within ±5 mm Hg (±0.7 kPa).

(C) The road load power shall be determined according to the procedure outlined in § 86.118 and adjusted according to the following if applicable.

(3) Where it is expected that more than 33 percent of the vehicles in an engine family will be equipped with air conditioning, the road load power listed above or as determined in paragraph (b)(2) of this section shall be increased by 10 percent for testing all test vehicles representing such an engine family if those vehicles are intended to be offered with air conditioning in production.

§ 86.130–78 Test sequence, general requirements.

The test sequence shown in Figure B78–10 shows the steps encountered as the test vehicle undergoes the procedures subsequently described to determine conformity with the standards set forth. Ambient temperature levels encountered by the test vehicle throughout the test sequence shall not be less than 68° F (20° C) nor more than 86° F (30° C). The vehicle shall be approximately level during all phases of the test sequence to prevent abnormal fuel distribution.

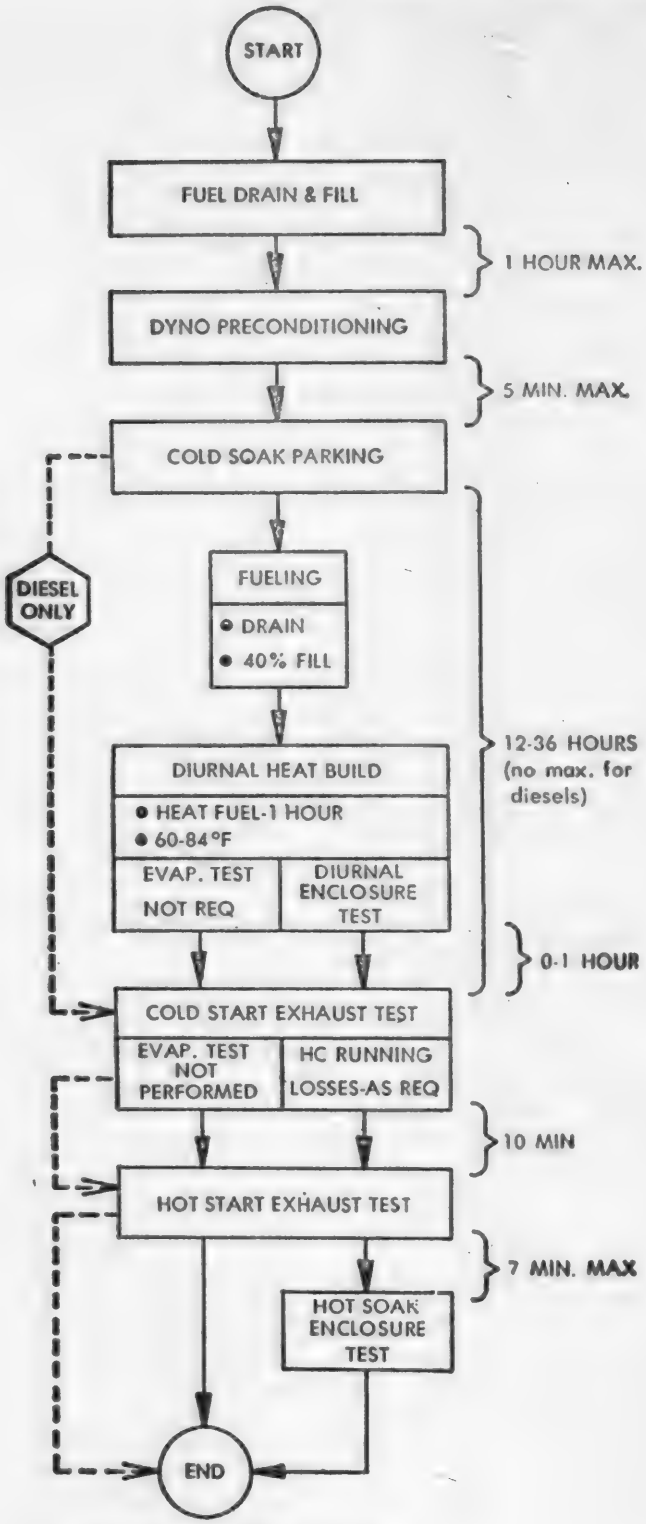


FIGURE B78-10 TEST SEQUENCE

§ 86.131–78 Vehicle preparation.

(a) For gasoline fueled vehicles prepare the fuel tank(s) for recording the temperature of the prescribed test fuel at the approximate mid-volume of the fuel.

(b) Provide additional fittings and adapters, as required, to accommodate a fuel drain at the lowest point possible in the tank(s) as installed on the vehicle.

§ 86.132–78 Vehicle preconditioning.

(a) The vehicle shall be moved to the test area and the following operations performed:

(1) The fuel tank(s) shall be drained through the provided fuel tank(s) drain(s) and filled to the prescribed "tank fuel volume" with the specified test fuel, § 86.113. For the above operations the evaporative emission control system shall neither be abnormally purged nor abnormally loaded.

(2) Within one hour of being fueled the vehicle shall be placed, either by being driven or pushed, on a dynamometer and operated through one Urban Dynamometer Driving Schedule test procedure, see § 86.115 and Appendix I. A gasoline fueled test vehicle may not be used to set dynamometer horsepower.

(3) For those unusual circumstances where additional preconditioning is desired by the manufacturer, such preconditioning may be allowed with the advance approval of the Administrator. The Administrator may also choose to conduct or require the conduct of additional preconditioning to insure that the evaporative emission control system is stabilized. The additional preconditioning shall consist of an initial one hour minimum soak and, one, two or three driving cycles of the UDDS, as described in paragraph (a)(2) of this section, each followed by a soak of at least one hour with engine off, engine compartment cover closed and cooling fan off. The vehicle may be driven off the dynamometer following each UDDS for the soak period.

(b) Within five minutes of completion of preconditioning the vehicle shall be driven off the dynamometer and parked. The vehicle shall be stored for not less than 12 hours nor for more than 36 hours (except diesel fueled vehicles which have no maximum time limitation) prior to the cold start exhaust test. (Gasoline fueled vehicles undergo a one hour diurnal heat build prior to the cold start exhaust test. A wait of up to one hour is permitted between the end of the diurnal heat build and the beginning of the cold start exhaust test. See § 86.130 and Figure B78–10.)

(c) Vehicles to be tested for evaporative emissions shall be processed in accordance with procedures in §§ 86.133 through 86.138. Vehicles to be tested for exhaust emissions only shall be processed according to §§ 86.133 through 86.137.

§ 86.133–78 Diurnal breathing loss test.

(a)(1) Following vehicle preparation and vehicle preconditioning procedures

described in §§ 86.131 and 86.132 the test vehicle shall be allowed to soak for a period of not less than 12 or more than 36 hours prior to the exhaust emission test. The diurnal test shall start not less than 10 or more than 35 hours after the end of the preconditioning procedure. The start of the exhaust test shall follow the end of the diurnal test within one hour.

(2) Gasoline fueled vehicles to be tested for exhaust emissions only, shall undergo the diurnal heat build. Since no evaporative measurements are necessary, an evaporative enclosure is not required.

(b) The evaporative emission enclosure shall be purged for several minutes immediately prior to the test.

NOTE.—If at anytime the hydrocarbon concentration exceeds 15,000 ppm C the enclosure should be immediately purged. This concentration provides a 4:1 safety factor against the lean flammability limit.

(c) The FID hydrocarbon analyzer shall be zeroed and spanned immediately prior to the test.

(d) If not already on, the evaporative enclosure mixing fan shall be turned on at this time.

(e) Immediately prior to the diurnal breathing loss test, the fuel tank(s) of the prepared vehicle shall be drained and recharged with the specified test fuel, § 86.113, to the prescribed "tank fuel volume," defined in § 86.078–2. The temperature of the fuel prior to its delivery to the fuel tank shall be between 50 and 60° F (10 and 16° C). The fuel tank cap(s) is not installed until the diurnal heat build begins.

(f) The test vehicle, with the engine shut off, shall be moved into the evaporative emission enclosure, the test vehicle windows and luggage compartments shall be opened, the fuel tank temperature sensor shall be connected to the temperature recording system, and, if required, the heat source shall be properly positioned with respect to the fuel tank(s) and/or connected to the temperature controller.

(g) The temperature recording system shall be started.

(h) The fuel may be artificially heated to the starting diurnal temperature.

(i) When the fuel temperature recording system reaches at least 58° F (14° C), immediately:

(1) Install fuel tank cap(s).

(2) Turn off purge blowers, if not already off at this time.

(3) Close and seal enclosure doors.

(j) When the fuel temperature recording system reaches 60±2° F (16±1.1° C), immediately:

(1) Analyze enclosure atmosphere for hydrocarbons and record. This is the initial (time=0 minutes) hydrocarbon concentration, C_{HCI}, § 86.143.

(2) Start diurnal heat build and record time. This commences the 60±2 minute test period.

(k) The fuel shall be heated in such a way that its temperature change conforms to the following function to within ±3° F (±1.6° C):

$F = T_o + 0.4t$

for SI units, $C = T_o + (2/9)t$

Where:

F = fuel temperature, ° F
C = fuel temperature, ° C
t = time since beginning of test, minutes.
T_o = initial temperature.

After 60±2 minutes of heating, the fuel temperature rise shall be 24±1° F (±0.5° C).

(l) The FID hydrocarbon analyzer shall be zeroed and spanned immediately prior to the end of the diurnal test.

(m) The end of the diurnal breathing loss test occurs 60±2 minutes after the heat build begins, paragraph (j)(2). Analyze the enclosure atmosphere for hydrocarbons and record. This is the final (time=60 minutes) hydrocarbon concentration, C_{HCf}, § 86.143. The time (or elapsed time) of this analysis shall be recorded.

(n) The heat source shall be turned off and the enclosure doors unsealed and opened.

(o) The heat source shall be moved away from the vehicle, if required, and/or disconnected from the temperature controller, the fuel tank temperature sensor shall be disconnected from the temperature recording system, the test vehicle windows and luggage compartments may be closed and the test vehicle, with the engine shut off, shall be removed from the evaporative emission enclosure.

(p) For vehicles with multiple tanks, the largest tank shall be designated as the primary tank and shall be heated in accordance with the procedures described in paragraph (k) of this section. All other tanks shall be designated as auxiliary tanks and shall undergo a similar heat build such that the fuel temperature shall be within 3°F (1.6°C) of the primary tank.

§ 86.134–78 Running loss test.

(a) If an engineering analysis or vehicle inspection indicates the possibility of evaporative emissions during vehicle operation, evaporative emission running loss measurements shall be made during the cold transient and stabilized portion of the exhaust emission test. Since running loss measurements cannot be made in the enclosure, the equipment described in § 86.177–17 shall be used to collect these emissions.

(1) The procedure in § 86.135 shall be followed.

(2) Prior to the initiation of the cold start exhaust emission test, the vapor loss measurement system shall be connected to all suspected sources of running loss evaporative emissions.

(3) The cold start transient and stabilized exhaust emission test portions shall be conducted according to the procedures of § 86.135 through § 86.137.

(4) Within one minute after the end of the stabilized exhaust emission test, the vapor loss measurement system shall be disconnected from the vehicle and the inlets and outlets sealed.

(5) Within one hour from the end of the running loss measurement, weigh the vapor collection traps.

§ 86.135–78 Dynamometer procedure.

(a) The dynamometer run consists of two tests, a "cold" start test after a minimum 12-hour and a maximum 36-hour soak according to the provisions of §§ 86.132 and 86.133 and a "hot" start test following the "cold" start test by 10 minutes. Engine startup (with all accessories turned off), operation over the driving schedule, and engine shutdown make a complete cold start test. Engine startup and operation over the first 505 seconds of the driving schedule complete the hot start test. The exhaust emissions are diluted with ambient air and a continuously proportional sample is collected for analysis during each phase. The composite samples collected in bags are analyzed for hydrocarbons (except diesel hydrocarbons which are analyzed continuously), carbon monoxide, carbon dioxide, and oxides of nitrogen. A parallel sample of the dilution air is similarly analyzed for hydrocarbon, carbon monoxide, carbon dioxide, and oxides of nitrogen.

(b) During dynamometer operation, a fixed speed cooling fan shall be positioned so as to direct cooling air to the vehicle in an appropriate manner with the engine compartment cover open. In the case of vehicles with front engine compartments, the fan shall be squarely positioned within 12 inches of the vehicle. In the case of vehicles with rear engine compartments (or if special designs make the above impractical), the cooling fan shall be placed in a position to provide sufficient air to maintain vehicle cooling. The fan capacity shall normally not exceed 5,300 cfm (2.50 m^3/s). If, however, the manufacturer can show that during field operation the vehicle receives additional cooling, and that such additional cooling is needed to provide a

representative test, the fan capacity may be increased or additional fans used if approved in advance by the Administrator.

(c) The vehicle speed as measured from the dynamometer rolls shall be used. A speed vs. time recording, as evidence of dynamometer test validity, shall be supplied on request of the Administrator.

(d) Practice runs over the prescribed driving schedule may be performed at test points, provided an emission sample is not taken, for the purpose of finding the minimum throttle action to maintain the proper speed-time relationship, or to permit sampling system adjustments.

NOTE.—When using two-roll dynamometers a truer speed-time trace may be obtained by minimizing the rocking of the vehicle in the rolls. The rocking of the vehicle changes the tire rolling radius on each roll. This rocking may be minimized by restraining the vehicle horizontally (or nearly so) by using a cable and winch.

(e) The drive wheel tires may be inflated up to a gauge pressure of 45 psi (310 kPa) in order to prevent tire damage. The drive wheel tire pressure shall be reported with the test results.

(f) If the dynamometer has not been operated during the 2-hour period immediately preceding the test it shall be warmed up for 15 minutes by operating at 30 mph (48 km/h) using a non-test vehicle or as recommended by the dynamometer manufacturer.

(g) If the dynamometer horsepower must be adjusted manually, it shall be set within 1 hour prior to the exhaust emissions test phase. The test vehicle shall not be used to make the adjustment. Dynamometers using automatic control of preselectable power settings may be set anythime prior to the beginning of the emissions test.

§ 86.136–78 Engine starting and restarting.

(a) *Gasoline fueled vehicles.* This paragraph (a) applies to gasoline fueled vehicles.

(1) The engine shall be started according to the manufacturer's recommended starting procedures. The initial 20 second idle period shall begin when the engine starts.

(2) *Choke operation:* (i) Vehicles equipped with automatic chokes shall be operated according to the manufacturer's operating instructions or owner's manual, including choke setting and "kick-down" from cold fast idle.

(ii) Vehicles equipped with manual chokes shall be operated according to the manufacturer's operating instructions or owner's manual.

(3) The transmission shall be placed in gear 15 seconds after the engine is started. If necessary, braking may be employed to keep the drive wheels from turning.

(4) The operator may use the choke, accelerator pedal, etc. where necessary to keep the engine running.

(5) If the manufacturer's operating instructions or owner's manual does not specify a warm engine starting procedure, the engine (automatic and manual choke engines) shall be starated by depressing the accelerator pedal about half way and cranking the engine until it starts.

(b) *Diesel fueled vehicles.* The engine shall be started according to the manufacturer's recommended starting procedures. The initial 20-second-idle period shall begin when the engine starts. The transmission shall be placed in gear 15 seconds after the engine is started. If necessary, braking may be employed to keep the drive wheels from turning.

(c) If the vehicle does not start after 10 seconds of cranking; cranking shall cease and the reason for failure to start shall be determined. The gas flow measuring device (or revolution counter) on the constant volume sampler (and the hydrocarbon integrater when testing diesel vehicles, see § 86.137, Dynamometer test runs) shall be turned off and the sample selector valves placed in the "standby" position during this diagnostic period. In addition, either the CVS should be turned off or the exhaust tube disconnected from the tailpipe during the diagnostic period.

(1) If failure to start is an operational error, the vehicle shall be rescheduled for testing from a cold start. If failure to start is caused by vehicle malfunction, corrective action of less than 30 minutes duration may be taken and the test continued. The sampling system shall be reactivated at the same time cranking is started. When the engine starts, the driving schedule timing sequence shall begin. If failure to start is caused by vehicle malfunction and the vehicle cannot be started, the test shall be voided, the vehicle removed from the dynamometer, corrective action taken, and the vehicle rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

(d) If the engine "false starts," the operator shall repeat the recommended starting procedure (such as resetting the choke, etc.).

(e) *Stalling:* (1) If the engine stalls during an idle period, the engine shall be restarted immediately and the test continued. If the engine cannot be started soon enough to allow the vehicle to follow the next acceleration as prescribed, the driving schedule indicator shall be stopped. When the vehicle restarts, the driving schedule indicator shall be reactivated.

(2) If the engine stalls during some operating mode other than idle, the driving schedule indicator shall be stopped, the vehicle shall then be restarted and accelerated to the speed required at that point in the driving schedule and the test continued. During acceleration to this point, shifting shall be performed in accordance with § 86.128.

(3) If the vehicle will not restart within 1 minute, the test shall be voided, the vehicle removed from the dynamometer, corrective action taken, and the vehicle rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

§ 86.137–78 Dynamometer test runs.

(a) The vehicle shall be allowed to stand with the engine turned off for a period of not less than 12 hours or more than 36 hours before the cold start exhaust emission test. The cold start exhaust test shall follow the diurnal breathing loss test by not more than 1 hour. The vehicle shall be stored prior to the emission test in such a manner that precipitation (e.g. rain or dew) does not occur on the vehicle. The complete dynamometer test consists of a cold start drive of 7.5 miles (12.1 km) and simulates a hot start drive of 7.5 miles (12.1 km). The vehicle is allowed to stand on the dynamometer during the 10 minute time period between the cold and hot start tests. The cold start test is divided into two periods. The first period, representing the cold start "transient" phase, terminates at the end of the deceleration which is scheduled to occur at 505 seconds of the driving schedule. The second period, representing the "stabilized" phase, consists of the remainder of the driving schedule including engine shutdown. The hot start test similarly consists of two periods. The period, representing the hot start "transient" phase, terminates at the same point in the driving schedule as the first period of the cold start test. The second period of the hot start test, "stabilized" phase, is assumed to be identical to the second period of the cold start test. Therefore, the hot start test terminates after the first period (505 seconds) is run.

(b) The following steps shall be taken for each test:

(1) Place drive wheels of vehicle on dynamometer without starting engine.

(2) Open the vehicle engine compartment cover and position the cooling fan.

(3) With the sample selector valves in the "standby" position connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.

(4) Start the Constant Volume Sampler (if not already on), the sample pumps, the temperature recorder, the vehicle cooling fan and the heated hydrocarbon analysis recorder (diesel only). (The heat exchanger of the constant volume sampler, if used, diesel hydrocarbon analyzer continuous sample line and filter (if applicable) should be preheated to their respective operating temperatures before the test begins.)

(5) Adjust the sample flow rates to the desired flow rate (minimum of 10 cfh, 0.28 m^3/hr) and set the gas flow measuring devices to zero.

NOTE.—CFV–CVS sample flowrate is fixed by the venturi design.

(6) Attach the flexible exhaust tube to the vehicle tailpipe(s).

(7) Start the gas flow measuring device, position the sample selector valves to direct the sample flow into the "transient" exhaust sample bag and the transient" dilution air sample bag (turn on

the diesel hydrocarbon analyzer system integrator and mark the recorder chart, if applicable) and start cranking the engine.

(8) Fifteen seconds after the engine starts, place the transmission in gear.

(9) Twenty seconds after the engine starts, begin the initial vehicle acceleration of the driving schedule.

(10) Operate the vehicle according to the dynamometer driving schedule (§ 86.115).

(11) At the end of the deceleration which is scheduled to occur at 505 seconds, simultaneously switch the sample flows from the "transient" bags to the "stabilized" bags, switch off gas flow measuring device No. 1 (and the diesel hydrocarbon integrator No. 1, mark the diesel hydrocarbon recorder chart) and start gas flow measuring device No. 2 (and diesel hydrocarbon integrator No. 2). As soon as possible transfer the "transient" exhaust and dilution air samples to the analytical system and process the samples according to § 86.140 obtaining a stabilized reading of the exhaust sample on all analyzers within 20 minutes of the end of the sample collection phase of the test.

(12) Turn the engine off 2 seconds after the end of the last declaration (at 1,369 seconds).

(13) Five seconds after the engine stops running, simultaneously turn off gas flow measuring device No. 2 (and the diesel hydrocarbon integrator No. 2, mark the hydrocarbon recorder chart, if applicable) and position the sample selector valves to the "standby" position. As soon as possible transfer the "stabilized" exhaust and dilution air samples to the analytical system and process the samples according to § 86.140 obtaining a stabilized reading of the exhaust sample on all analyzers within 20 minutes of the end of the sample collection phase of the test.

(14) Immediately after the end of the sample period turn off the cooling fan and close the engine compartment cover.

(15) Turn off the CVS or disconnect the exhaust tube from the tailpipe of the vehicle.

(16) Repeat the steps in paragraph (b) (2) through (10) of this section for the hot start test, except only one evacuated sample bag is required for sampling exhaust gas and one for dilution air. The step in paragraph (b) (7) of this section shall begin between 9 and 11 minutes after the end of the sample period for the cold start test.

(17) At the end of the deceleration which is scheduled to occur at 505 seconds, simultaneously turn off gas flow measuring device No. 1 (and diesel hydrocarbon integrator No. 1, mark the diesel hydrocarbon recorder chart, if applicable) and position the sample selector valve to the "standby" position. (Engine shutdown is not part of the hot start test sample period.)

(18) As soon as possible transfer the hot start "transient" exhaust and dilution air samples to the analytical system and process the samples according to § 86.140 obtaining a stabilized reading of the exhaust sample on all analyzers within 20 minutes of the end of the sample collection phase of the test.

(19) Disconnect the exhaust tube from the vehicle tailpipe(s) and drive vehicle from dynamometer.

(20) The constant volume sampler may be turned off, if desired.

(21) Vehicles to be tested for evaporative emissions will proceed according to § 86.138. For all others this completes the test sequence.

§ 86.138–78 Hot soak test.

The hot soak evaporative emission test shall be conducted immediately following the hot transient exhaust emission test.

(a) Prior to the completion of the hot start transient exhaust emission sampling period, the evaporative emission enclosure shall be purged for several minutes.

(b) The FID hydrocarbon analyzer shall be zeroed and spanned immediately prior to the test.

(c) If not already on, the evaporative enclosure mixing fan shall be turned on at this time.

(d) Upon completion of the hot transient exhaust emission sampling period, the vehicle engine compartment cover shall be closed, the cooling fan shall be moved, the vehicle shall be disconnected from the dynamometer and exhaust sampling system, and then driven at minimum throttle to the vehicle entrance of the enclosure.

(e) The vehicle's engine must be stopped before any part of the vehicle enters the enclosure. The vehicle may be pushed or coasted into the enclosure.

(f) The test vehicle windows and luggage compartments shall be opened, if not already open.

(g) The temperature recording system shall be started and the time of engine shut off shall be noted on the evaporative emission hydrocarbon data recording system.

(h) The enclosure doors shall be closed and sealed within two minutes of engine shutdown and within seven minutes after the end of the exhaust test.

(i) The 60±0.5 minute hot soak begins when the enclosure doors are sealed. The enclosure atmosphere shall be analyzed and recorded. This is the initial (time=0 minutes) hydrocarbon concentration, C_{HCi}, for use in calculating evaporative losses, see § 86.143.

(j) The test vehicle shall be permitted to soak for a period of one hour in the enclosure.

(k) The FID hydrocarbon analyzer shall be zeroed and spanned immediately prior to the end of the test.

(l) At the end of the 60±0.5 minute test period, again analyze the enclosure atmosphere and record time. This is the final (time=60 minutes) hydrocarbon concentration, C_{HCf}, for use in calculating evaporative losses, see § 86.143. This operation completes the evaporative emission measurement procedure.

§ 86.139–78 [Reserved]

§ 86.140–78 Exhaust sample analysis.

The following sequence of operations shall be performed in conjunction with each series of measurements:

(a) Zero the analyzers and obtain a stable zero reading. Recheck after tests.

(b) Introduce span gases and set instrument gains. In order to avoid corrections, span and calibrate at the same flow rates used to analyze the test sample. Span gases should have concentrations equal to 75 to 100 percent of full scale. If gain has shifted significantly on the analyzers, check the calibrations. Show actual concentrations on chart.

(c) Check zeros; repeat the procedure in paragraphs (a) and (b) of this section if required.

(d) Check flowrates and pressures.

(e) Measure HC, CO, CO_2 and NO_x concentrations of samples.

(f) For diesel vehicles, continuously record (integrate electronically if desired) dilute hydrocarbon emission levels during test. Background samples are collected in sample bags and analyzed as above.

(g) Check zero and span points. If difference is greater than 2 percent of full scale, repeat the procedure in paragraphs (a) through (f) of this section.

§ 86.141–78 [Reserved]

§ 86.142–78 Records required.

The following information shall be recorded with respect to each test:

(a) Test number.

(b) System or device tested (brief description).

(c) Date and time of day for each part of the test schedule.

(d) Instrument operator.

(e) Driver or operator.

(f) Vehicle: Make—Vehicle identification number—Model year—Transmission type—Odometer reading—Engine displacement—Engine family—Evap. family—Idle rpm—Fuel system (fuel injection, nominal fuel tank(s) capacity, fuel tank(s) location, number of carburetors, number of carburetor barrels)—Inertia loading—Actual curb weight recorded at 0 miles—Actual road load at 50 mph (80 km/h) and drive wheel tire pressure, as applicable.

(g) Indicated road load power absorption at 50 mph (80 km/h) and dynamometer serial number. As an alternative to recording the dynamometer serial number, a reference to a vehicle test cell number may be used, with the advance approval of the Administrator, provided the test cell records show the pertinent information.

(h) All pertinent instrument information such as tuning—gain—serial number—detector number—range. As an alternative, a reference to a vehicle test cell number may be used, with the advance approval of the Administrator, provided test cell calibration records show the pertinent instrument information.

(i) Recorder charts: Identify zero, span, exhaust gas, and dilution air sample traces.

(j) Test cell barometric pressure, ambient temperature and humidity.

NOTE.—A central laboratory barometer may be used: *Provided*, That individual test cell barometric pressures are shown to be within ±0.1 percent of the barometric pressure at the central barometer location.

(k) Fuel temperatures, as prescribed.

(l) Pressure of the mixture of exhaust and dilution air entering the CVS metering device, the pressure increase across the device, and the temperature at the inlet. The temperature may be recorded continuously or digitally to determine temperature variations.

(m) The number of revolutions of the positive displacement pump accumulated during each test phase while exhaust samples are being collected. The number of standard cubic feet metered by a critical flow venturi during each test phase would be the equivalent record for a CFV–CVS.

(n) The humidity of the dilution air.

NOTE.—If conditioning columns are not used (see § 86.122 and § 86.144) this measurement can be deleted. If the conditioning columns are used and the dilution air is taken from the test cell, the ambient humidity can be used for this measurement.

(o) Temperature set point of the heated sample line and heated hydrocarbon detector temperature control system (for diesel vehicles only).

§ 86.143–78 Calculations; evaporative emissions.

The calculation of the net hydrocarbon mass change in the enclosure is used to determine the diurnal and hot soak mass emissions. The mass is calculated from initial and final hydrocarbon concentrations in ppm carbon, initial and final enclosure ambient temperatures, initial and final barometric pressures, and net enclosure volume using the following equation:

$$M_{HC} = kV_n \times 10^{-4}\left[\frac{C_{HCf}P_{Bf}}{T_f} - \frac{C_{HCi}P_{Bi}}{T_i}\right]$$

Where:

M_{HC} = hydrocarbon mass, g.

C_{HC} = hydrocarbon concentration as ppm carbon.

V_n = net enclosure volume, ft³ (m³) as determined by subtracting 50 ft³ (1.42 m³) (volume of vehicle with trunk and windows open) from the enclosure volume. A manufacturer may use the measured volume of the vehicle (instead of the nominal 50 ft³) with advance approval by the Administrator: *Provided*, The measured volume is determined and used for all vehicles tested by that manufacturer.

P_B = barometric pressure, in. Hg (kPa).

T = enclosure ambient temperature, R (K).

k = .208 (12+H/C)

for SI units, k = 1.2 (12+H/C).

Where:

H/C = Hydrogen-carbon ratio.

H/C = 2.33 for diurnal emissions.

H/C = 2.2 for hot soak emissions.

i = indicates initial reading.

f = indicates final reading.

§ 86.144–78 Calculations; exhaust emissions.

The final reported test results shall be computed by use of the following formula:

(a) For light duty vehicles and light duty trucks:

$$Y_{wm} = (0.43\ Y_{ct} + 0.57\ Y_{ht} + Y_s)/7.5$$

Where:

Y_{wm} = Weighted mass emissions of each pollutant, i.e., HC, CO, or NOx, in grams per vehicle mile.

Y_{ct} = Mass emissions as calculated from the "transient" phase of the cold start test, in grams per test phase.

Y_{ht} = Mass emissions as calculated from the "transient" phase of the hot start test, in grams per test phase.

Y_s = Mass emissions as calculated from the "stabilized" phase of the cold start test, in grams per test phase.

(b) The mass of each pollutant for each phase of both the cold start test and the hot start test is determined from the following:

(1) Hydrocarbon mass:

$$HC_{mass} = V_{mix} \times Density_{HC} \times (HC_{conc}/1{,}000{,}000)$$

(2) Oxides of nitrogen mass:

$$NOx_{mass} = V_{mix} \times Density_{NO_2} \times K_H \times (NOx_{conc}/1{,}000{,}000)$$

(3) Carbon monoxide mass:

$$CO_{mass} = V_{mix} \times Density_{CO} \times (CO_{conc}/1{,}000{,}000)$$

(4) Carbon dioxide mass:

$$CO_{2mass} = V_{mix} \times Density_{CO_2} \times (CO_{2conc}/100)$$

(c) Meaning of symbols:

(1) HC_{mass} = Hydrocarbon emissions, in grams per test phase.

$Density_{HC}$ = Density of hydrocarbons is 16.33 g/ft³ (.5767 kg/m³), assuming an average carbon to hydrogen ratio of 1:1.85, at 68° F (20° C) and 760 mm Hg (101.3 kPa) pressure.

HC_{conc} = Hydrocarbon concentration of the dilute exhaust sample corrected for background, in ppm carbon equivalent, i.e., equivalent propane × 3.

$$HC_{conc} = HC_e - HC_d(1-1/DF)$$

Where:

HC_e = Hydrocarbon concentration of the dilute exhaust sample or, for diesel, average hydrocarbon concentration of the dilute exhaust sample as calculated from the integrated HC traces, in ppm carbon equivalent.

HC_d = Hydrocarbon concentration of the dilution air as measured, in ppm carbon equivalent.

(2) NOx_{mass} = Oxides of nitrogen emissions, in grams per test phase.

$Density_{NO_2}$ = Density of oxides of nitrogen is 54.16 g/ft³ (1.913 kg/m³), assuming they are in the form of nitrogen dioxide, at 68° F (20° C) and 760 mm Hg (101.3 kPa) pressure.

NOx_{conc} = Oxides of nitrogen concentration of the dilute exhaust sample corrected for background, in ppm.

$$NOx_{conc} = NOx_e - NOx_d\ (1-1/DF)$$

Where:

NOx_e = Oxides of nitrogen concentration of the dilute exhaust sample as measured, in ppm.

NOx_d = Oxides of nitrogen concentration of the dilute air as measured, in ppm.

(3) CO_{mass} = Carbon monoxide emissions, in grams per test phase.

$Density_{CO}$ = Density of carbon monoxide is 32.97 g/ft³ (1.164 kg/m³), at 68° F (20°C) and 760 mm Hg (101.3 kPa) pressure.

CO_{conc} = —Carbon monoxide concentration of the dilute exhaust sample corrected for background, water vapor, and CO_2 extraction, in ppm.

$$CO_{conc} = CO_e - CO_d\ (1-1/DF)$$

Where:

CO_e = Carbon monoxide concentration of the dilute exhaust sample volume corrected for water vapor and carbon dioxide extraction, in ppm. The calculation assumes the carbon to hydrogen ratio of the fuel is 1:1.85.

$$CO_e = (1-0.01925\ CO_{2e} - 0.000323\ R)\ CO_{em}$$

Where:

CO_{em} = Carbon monoxide concentration of the dilute exhaust sample as measured, in ppm.

CO_{2e} = Carbon dioxide concentration of the dilute exhaust sample, in percent.

R = Relative humidity of the dilution air, in per cent (see § 86.142(n)).

CO_d = Carbon monoxide concentration of the dilution air corrected for water vapor extraction, in ppm.

$$CO_d = (1-0.000323\ R)\ CO_{dm}$$

Where:

CO_{dm} = Carbon monoxide concentration of the dilution air sample as measured, in ppm.

NOTE.—If a CO instrument which meets the criteria specified in § 86.111 is used and the conditioning column has been deleted, CO_{em} can be substituted directly for CO_e and CO_{dm} can be substituted directly for CO_d.

(4) CO_{2mass} = Carbon dioxide emissions, in grams per test phase.

$Density_{CO_2}$ = Density of carbon dioxide is 51.85 g/ft³ (1.843 kg/m³), at 68° F (20° C) and 760 mm Hg (101.3 kPa) pressure.

CO_{2conc} = Carbon dioxide concentration of the dilute exhaust sample corrected for background, in percent.

$$CO_{2conc} = CO_{2e} - CO_{2d}\ (1-1/DF)$$

Where:

CO_{2d} = Carbon dioxide concentration of the dilution air as measured, in percent.

(5) $DF = 13.4/[CO_{2e} + (HC_e + CO_e)\ 10^{-4}]$

K_H = Humidity correction factor.

$K_H = 1/[1-0.0047(H-75)]$

for SI units $= 1/[1-0.0329(H-10.71)]$

Where:

H = Absolute humidity in grains (grams) of water per pound (kilogram) of dry air.

$$H = [(43.478)R_a \times P_d]/[P_B - (P_d \times R_a/100)]$$

for SI units, $H = [(6.211)R_a \times P_d]/[P_B - (P_d \times R_a/100)]$

R_a = Relative humidity of the ambient air, in percent.

P_d = Saturated vapor pressure, in mm Hg (kPa) at the ambient dry bulb temperature.

P_B = Barometric pressure, in mm Hg (kPa).

V_{mix} = Total dilute exhaust volume in cubic feet per test phase corrected to standard conditions (528 R) (293 K) and 760 mm Hg (101.3 kPa)).

For PDP-CVS, V_{mix} is:

$$V_{mix}=V_o\times\frac{N(P_B-P_A)\ (528\ R)}{(760\ \text{mm Hg})\ (T_P)}$$

for SI units,

$$V_{mix}=V_o\times\frac{N(P_B-P_A)\ (293.15\ K)}{(101.325\ \text{kPa})\ (T_P)}$$

Where:

V_o=Volume of gas pumped by the positive displacement pump, in cubic feet (m^3) per revolution. This volume is dependent on the pressure differential across the positive displacement pump.

N=Number of revolutions of the positive displacement pump during the test phase while samples are being collected.

P_B=Barometric pressure, in mm Hg (kPa).

P_A=Pressure depression below atmospheric measured at the inlet to the positive displacement pump, in mm Hg (kPa) (during an idle mode).

T_P=Average temperature of dilute exhaust entering positive displacement pump during test, R(K).

(d) Example calculation of mass values of exhaust emissions using positive displacement pump:

(1) For the "transient" phase of the cold start test assume the following: V_o=0.29344 ft^3/revolution; N=10,485; R=48.0%; R_a=48.2%; P_B=762 mm Hg; P_d=22.225 mm Hg; P_A=70 mm Hg; T_P=570 R; HC_e=105.8 ppm, carbon equivalent; NO_{xe}=11.2 ppm; CO_{em}=306.6 ppm; CO_{2e}=1.43%; HC_d=12.1 ppm; NO_{xd}=0.8 ppm; CO_{dm}=15.3 ppm.

Then:

V_{mix}=(0.29344) (10,485) (762–70) (528)/(760) (570)=2595.0 ft^3 per test phase.

H=(43.478) (48.2) (22.225)/[762 −(22.225×48.2/100)]

K_H=1/[1−0.0047(62−75)]=0.9424

CO_e=[1−0.01925 (1.43) −0.000323 (48)] 306.0=293.4 ppm

CO_d=[1−0.000323 (48)] 15.3=15.1 ppm

DF=13.4/[1.43+(105.8+293.4) ×10^{-4}]=9.116

HC_{conc}=105.8−12.1(1−1/9.116)=95.03 ppm.

HC_{mass}=(2595) (16.33) (95.03/1,000,000) =4.027 grams per test phase.

NO_{xconc}=11.2–0.8 (1–1/9.116)=10.49 ppm

NO_{xmass}=(2595) (54.16) (10.49/1,000,000) (0.9424)=1.389 grams per test phase.

CO_{conc}=293.4–15.1 (1–1/9.116)=280.0 ppm

CO_{mass}=(2595) (32.97) (280/1,000,000)= 23.96 grams per test phase.

(2) For the stabilized portion of the cold start test assume that similar calculations resulted in the following:

HC_{mass}=0.62 grams per test phase

NO_{xmass}=1.27 grams per test phase

CO_{mass}=5.98 grams per test phase

(3) For the "transient" portion of the hot start test assume that similar calculations resulted in the following:

HC_{mass}=0.51 grams per test phase

NO_{xmass}=1.38 grams per test phase

CO_{mass}=5.01 grams per test phase

(4) Weighted mass emission results:

HC_{wm}=[(0.43) (4.027)+(0.57) (0.51+ 0.62]/7.5=0.352 grams per vehicle mile.

NO_{xwm}=[(0.43) (1.389)+(0.57) (1.38)+ 1.27]/7.5=0.354 grams per vehicle mile.

CO_{wm}=[(0.43) (23.96)+(0.57) (5.01)+ 5.98]/7.5=2.55 grams per vehicle mile.

§ 86.145–78 [Reserved]

§§ 86.177–1 through 86.177–4 [Deleted]

13. Sections 86.177–1, 86.177–2, 86.177–3 and 86.177–4 are deleted.

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